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and
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The Outlook

Anti-tank Weapons

IF the Army were possessed of its own ground-attack corps of aircraft, it would have been possible for Capt. Margesson to tell the House of Commons what steps that corps was taking to deal with the German Mark 4 tanks in Libya when he introduced the Army Estimates on February 19th. As things are, he was only able to talk about the Army's two-pounder anti-tank gun, and to add that work was proceeding on a still larger tank than those we had previously produced and on an anti-tank gun with even greater penetrating power.

Perhaps, when the Air Estimates are debated, Sir Archibald Sinclair will be able to add some information about what the Air Force is doing to deal with enemy heavy tanks, but it is irritating to have this subject split in two, so to speak, for Rommel's Mark 4 monsters have presented us with a problem, and it is a single question of tactics to consider how best the Eighth Army and its air collaborators can deal with them.

It is admitted that air bombing does not provide the solution, for the tank is an elusive target for a bomb. The Air Force has believed that so far the best contribution it could make in the campaign was to cut off the supplies of enemy fuel as far as possible, and this policy has had some success. But Rommel has still retained his mobility, and when he retires he shortens his own lines of communications and lengthens ours. That must circumscribe to some extent our power of bringing up our own larger tanks and more potent guns to the firing line. Our 25-pounder field gun will deal with any tanks when it can get at them, but it has not always been able to get at them.

It certainly seems that a shell-gun in an aircraft of sufficiently large calibre (probably a minimum of 37 mm.) would be the best solution. The 20 mm. gun has knocked out very many of the German lighter vehicles, but the aircraft equipped with it have found it useless against the thick armour of the German heavy tanks. If and when we can despatch aircraft to Libya with guns of 40 mm. upwards, there seems no reason why German resistance should not be speedily overcome. But one wonders why proper provision was not made for the needs of the Army months ago.

Some Relief

MR. CHURCHILL is always honest in admitting national disasters and setbacks, but he is also ingenious in extracting what comfort can be sucked from a new situation. The escape of the three German warships from Brest to German ports has, he said, brought relief to the Admiralty, and this can be well understood. It has also brought relief to the Royal Air Force, which in the past ten months has sent 3,299 individual aircraft to bomb the ships in Brest, losing 43 of them and 247 men.

Actually, the number of machines lost during those ten months was only one more than the number which we lost in the few hectic hours while we were attacking the German flotilla on its passage through the Channel, but the raids on Brest cost us a number of our largest bombers with their highly trained crews. No doubt it will be a relief to the men of Bomber Command not to have to set out for a while and brave the absolute inferno of *flak* and fighters which have saved the warships from destruction in Brest.

None the less, there is no doubt that Coastal Command

is now on the track of the ships, nosing out the lairs to which they have betaken themselves, and it is equally certain that there will be more bombing attacks on them when they have been found. They may have gone to three separate dockyards, all probably farther away from our bases than is Brest, and so may call for even greater efforts by Bomber Command.

A New Production Minister

COLONEL J. J. LLEWELLIN is the third Minister for Aircraft Production since the M.A.P. was started, and has often been named as suited to his new post. While it is true that ultimately the fate of our aircraft output, and that is almost equivalent to saying the fate of the country, is in the hands of the permanent officials and of the aircraft industry, the political head can exert a very marked influence, as was proved by the first Minister for Aircraft Production, Lord Beaverbrook. A man with drive and energy can electrify a whole industry, but cynics might retort that when the current is switched off, everything comes to a standstill.

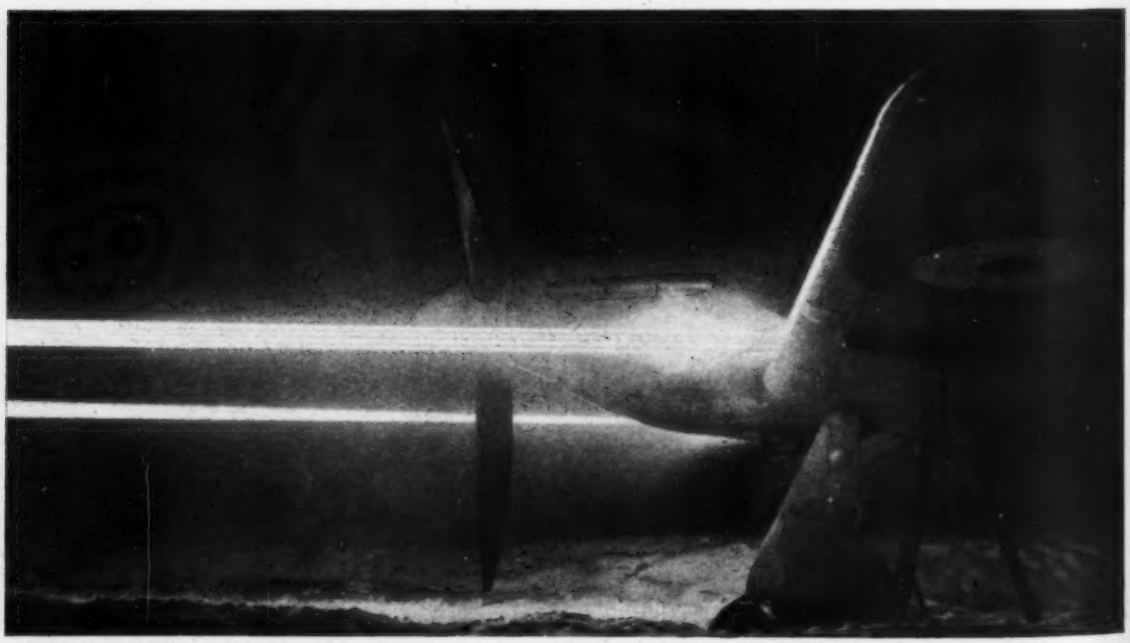
The great merit of Lord Beaverbrook's régime was that he concentrated on fighters and got us the numbers just in time for the Battle of Britain. That to do so he had to be ruthless, and to relegate for a time to second place the production of other types, is perfectly true. But bombers would not have saved us during that critical period ; the fighters did.

It was to Lt. Col. Moore-Brabazon that fell the task of speeding up and planning the long-range production of bigger types to give us the long-range heavy bombers that were to give the Germans our reply to the large-scale raids on London, Portsmouth, Southampton, Plymouth, Liverpool and Coventry. That programme, as he told a conference as recently as Friday of last week, is now well under way. Col. Moore-Brabazon is held by many to have concentrated too much on the "heavies," and to have neglected the medium bomber. That uneasiness is natural if unjust because a Production Minister's job is production and not the settlement of types to be produced. It would, however, be a serious mistake if the lighter types were put aside entirely in favour of the more devastating but less manœuvrable class of four-engined bomber. The picture of the war changes with such bewildering rapidity that it is never safe to disregard *any* type, nor do we believe that this is being done.

If the twin-engined Hampdens and the Whitleys are to cease production, and the four-engined types such as Stirlings and Halifaxes are to take their place, that is surely no matter for uneasiness, since the policy is dictated by experts of the Air Staff after serious consideration. The Wellington which is continued is still capable of good work within its own class, and several American types will supplement it. Not only so, but there are other "home-grown" types ready to step into any intermediate gaps which may reveal themselves as the war progresses.

There will be general regret in the aircraft industry at the departure of Lt. Col. Moore-Brabazon, a man exceptionally well versed in aircraft matters. If he did not infuse this department with the "buzz" of his predecessor, he did at any rate produce steady, methodical progress after the inevitable aftermath of the Beaverbrook tonic had worn off. Production methods have undoubtedly been improved, and Col. Moore-Brabazon quoted the case of an unnamed fighter, the man-hours for the production of which have been halved.

Col. J. J. Llewellin, C.B.E., M.C., T.D., M.A., M.P., the new Minister for Aircraft Production, has had a distinguished political career, and is a barrister. Three weeks previous to his new appointment he was elected President of the Board of Trade, but his knowledge of the Ministry he is now to control is considerable, for he was Parliamentary Secretary to the Ministry of Aircraft Production from 1940 and has occupied many important Government posts. We wish him well.



HITTING POWER : A Hurricane firing a burst of 1,600 rounds from its eight Brownings at night. The ammunition included one tracer in every four rounds.

War in the Air

Cleaning the 4.5in. twin-turreted dual-purpose guns on an aircraft carrier.

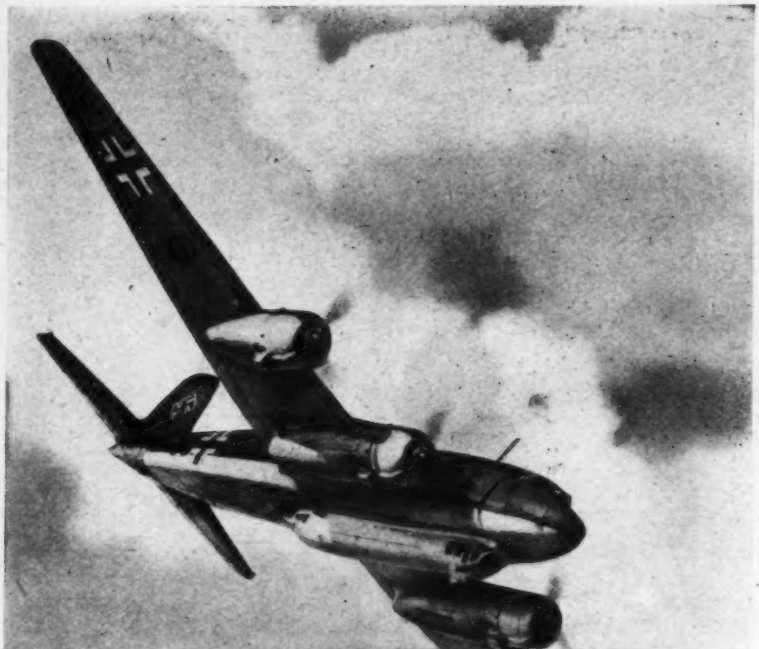
A Kittyhawk Victory : T.S.R.'s and Italian Warships : Bombing in Sumatra : Japanese Air Raids on Darwin

LAST week the excitement aroused by the fall of Singapore and the escape of the German warships through the Channel prevented us from alluding to a really great air battle over the Libyan desert. Terrific credit must go to the American fighter type used by the British and Australians, namely, the Curtiss Kittyhawk with Allison water-cooled engine. This machine is a considerable improvement on the Tomahawk, which has also done very well in the Middle East. The British formation was composed of 18 Kittyhawks drawn from two squadrons, one R.A.F. and the other R.A.A.F. They came upon a mixed lot of Axis aircraft, numbering about 30 machines, just about to strafe our ground troops. The Kittyhawks dived upon them and slew them. The whole fight only lasted five minutes, and one of our pilots counted six enemy machines hitting the ground in the same number of seconds. He could also see our men on the ground throwing their hats into the air in exultation as they saw the would-be killers thus killed off. The Kittyhawks shot down five Me 109s, 14 Macchi 200s, and one Breda 65. All the other enemy machines, including Macchi 200s and 202s, Me 109s, and Ju 87s, were damaged. Every one of our pilots bagged something, and the only damage suffered by our men was a cannon shot in the tail of one of the Australians. Obviously most of the enemy pilots were Italians, but there may have been some Germans among them. The morale of the *Regia Aeronautica* will hardly be improved by this severe defeat.

The Axis, which in this case must mean the Italian Navy, has met with another nasty rebuff in the Mediterranean. Although the usual British route to the Middle East is round the Cape, there are occasions when urgent convoys have to face the dangers of the direct route. Of course the enemy air reconnaissance quickly reports the approach of such a convoy. Such a case occurred on February 13th, and the first boastful but highly mendacious Italian reports of what happened made the public a little anxious, well accustomed as everybody now is to Italian methods of publicity. The operation lasted for three days, at the end of which our Admiralty published the true facts. The worst thing was that two of the merchantmen were so disabled by air attack that they had to be sunk by our own forces, but the loss of their cargoes was the only loss sustained on our side, except for superficial damage to one of H.M. ships.

The Italians sent both surface war-

NAVAL NOMADS : Fairey Albacores of the Fleet Air Arm flying over the Libyan desert.



The Focke-Wulf Fw 200C Condor. The bomber employed by the *Luftwaffe* for long-range action against our shipping in the Atlantic. Developed from the civil Condor which made record flights to New York and Tokio, the type is in quantity production. The power plants are four Bramo Fafnir radial engines of 1,000 h.p. each. Armament includes several machine guns and automatic cannons. A crew of six is carried. For a machine of its size—all-up weight is in the region of 38,000 lb.—it is said to be highly manœuvrable, but when fully loaded the take-off is prolonged. De-icing equipment is fitted to all the leading edges and the vital parts are protected by armour plate.

ships and aircraft against the convoy, and made great efforts to inflict serious damage, but their ships never got within gunshot range of the convoy, and only the aircraft were able to drive home their attacks. Five of these aircraft were certainly shot down, and four more were probably destroyed. Then on the night of February 14th British naval aircraft with their torpedoes came into the picture once more. They found the enemy cruisers and destroyers, and scored hits on two of the former and one of the latter. One of the enemy cruisers was seen to be on fire. But that was not the end of the story, for one of our submarines intercepted the Italians on their way back to harbour, and scored two torpedo hits on an eight-inch gun cruiser. One wonders what the Italian strength in cruisers fit for sea amounts to by this time. Quite a number have been damaged in the last few months.

A serious loss to the United Nations is the district of Palembang in Sumatra, the chief oil-producing centre in the Netherlands East Indies. The Japanese first sent parachute troops against it, but they seem to have been wiped out by the defenders. Then more ordinary troops were landed from transports, and they captured the place. The Dutch destroyed everything possible before they had to retire, and so the Japanese will not get oil from there, at least for a considerable time, but the loss of the oil is no light blow to our own side. Though the United Nations possess or control the main oil-producing regions of the world, the consumption in wartime is so enormous that every restriction of supply is a more or less serious matter. Moreover, the damage to the Palembang plant, supposing that the enemy cannot repair it, must postpone the day when the world will get into straight working order again after the war.

The Japanese did not bring off this success without appreciable losses. American, British and Dutch bombers attacked the Japanese transports and their naval escort, and hit two cruisers and five transports. Each Japanese warship which is damaged or sunk reduces the task which the United fleets will have to undertake when they are able to assume the offensive in the Pacific Ocean. The losses of the Japanese Navy have not been light up to date, and, though they still hold the upper hand of the combined fleets opposed to them, the Japanese replacement programme must be of a very modest order compared with the efforts and capabilities of Britain and the United States.

It has been authoritatively announced in Batavia that up to February 14th 109 Japanese ships were sunk, 28 probably sunk, and 45 damaged. These included seven cruisers, 13 destroyers, one aircraft carrier, six submarines, and 52 transports sunk, two battleships probably sunk, and two damaged.

Air Raids on Darwin

DARWIN was twice bombed by the Japanese on February 19th. The first raid, in the morning, lasted an hour, and was made by 72 twin-engined bombers escorted by fighters. In the afternoon there was a raid by 21 twin-engined bombers. Four enemy aircraft were shot down.

This bombing attack was not unexpected, but it comes to the whole Empire as a shock. London and many other British cities are only too familiar with air raids, and, of course, there is far more in a large British city that is of value than there could possibly be in a place like Darwin, which had very little importance before individual flights and commercial airways brought it into the limelight. Since then it has become a military centre. But, without doubt, every British citizen throughout the Empire, while full of admiration for the way in which Australians have fought in the Middle and Far East, liked to think that the homeland of these brave men was outside the danger zone.

The Japanese have a particular antipathy for the Australians, whose "White Australia" policy they resent. The comparatively small home islands of Japan are overpopulated, and when the Japanese looked round for means of expansion the large spaces and small population of Australia were a constant irritation and temptation. Up till a very short time ago there lay between the

crowded acres of Nippon and the open spaces of Australia the sea power of Britain. For the moment the Japanese have removed that obstacle, and it was only to be expected that they would vent their spite on Australia. But an invasion of that island continent is quite a different matter, and Mr. Churchill was probably right when he said that the Japanese are hardly likely to attempt such a thing in the near future. And Japanese prospects can only contemplate a future which is not distant. British and American shipbuilding goes on apace.

The Struggle for Java

THE Japanese have been pushing forward with their policy of "making hell while the sun shines," and since the capture of Singapore have started great efforts against Java and Rangoon. Obviously their object is to seize as much as possible before the United Nations recover command of the seas; but as the leaders of Nippon must know as well as anybody that that must happen sooner or later (sooner, we hope), it is not clear what they expect the final outcome to be. Once the American and British fleets with their gallant Dutch allies regain command of the seas, all these widespread Japanese expeditions will be just so many hostages to fortune.

For the moment Java would be a great prize, and the enemy have tried to establish bases for assailing it from both east and west, from Sumatra in the West and from Bali in the East. There has been a stiff fight off Bali, but at the moment of writing the actual Japanese losses are not clear. It is certain, however, that the troopships and their escort of cruisers and destroyers were heavily attacked from the air and by surface warships. Netherlands cruisers and destroyers, helped by half a dozen American destroyers, engaged the enemy, and undoubtedly did them serious damage. The Japanese losses, when they can be definitely established, are in addition to those mentioned earlier in this article.

United States aircraft also made heavy and destructive attacks. Bombers of an unspecified category took part, as well as Fortresses and dive-bombers, while P40 fighters kept guard overhead during some of the attacks and shot down a number of Japanese aircraft. The American losses were light, according to the first reports received. Consequently the first attempts of the Japanese to secure a foothold on the island and to capture the airfield of Den Pasar, the only good airfield in the island, were not a success. They must have lost large numbers of soldiers.

Dutch aircraft have also been disputing the Japanese attempts to advance in Sumatra and to raid air bases in Java, and the balance of success seems to have lain with our allies. There was one case, near Bali it seems, in which a Dutch pilot rammed his opponent and then made a safe descent himself. The Dutch are fighting with the utmost determination and with a fine aggressive spirit.

ENEMY AIR LOSSES TO FEB. 21st.

	Over G.B.	Over Continent	Middle East	Far East
Feb. 15	1	0	6	0
,, 16	1	0	0	0
,, 17	0	2	0	0
,, 18	1	0	0	0
,, 19	1	0	0	4
,, 20	0	1	0	0
,, 21	0	0	2	0
	4	3	8	4

Totals: North, 5,651; Middle East, over 3,507; Far East, 231.

BILINGUISTS: Between battles Polish pilots learn some more English from the Station schoolmaster.

Aircraft in Burma

IN the meantime the fighting in Burma is not going too well for the defence, though the British and Indian troops are fighting desperately to hold up the Japanese advance. Since the fall of Singapore the enemy must have large bodies of troops available to hurl against that front. The loss of Rangoon is evidently being considered as a possibility, and therefore arrangements have been made for using another route to send supplies to China. Rangoon is no longer considered as the inevitable port of entry for those supplies, and the entrance to it has been mined.

There are, of course, considerable possibilities about the Chinese force in the Shan hills, and its threat to the Japanese in Siam, but so far these have not taken material shape, and all the heavy fighting has been in Lower Burma, round the rivers which lie between Siam and Rangoon. Emphasis has been laid in most recent reports on the strength of the air support which our troops round the Bilin River have been receiving, and of the encouraging effect which this has had on our infantry. The American volunteer airmen have been doing grand work there.

It seems that there is still a natural, but not very intelligent, desire on the part of British soldiers to see our aircraft at work with their own eyes. It often happens—probably it is usually the case, as it was at Dunkerque—that aircraft can do their best service to the Army by working out of sight of the troops on the ground, and steps ought to be taken by the authorities to make the men understand this. The Army evidently has not enough comprehension of air activities, and it may well be that the Air Force, for its part, is inclined to carry on its work in its own way without sufficient understanding of what the soldiers want. However, in Lower Burma things seem satisfactory in that respect at the present.

In Libya there has been no marked change in the situation, but lately the weather there has improved, and has given our fighters a chance to protect our advanced troops during daylight operations

BRITISH AIR LOSSES TO FEB. 21st.

	Over G.B. A'crft.	Over Continent B'brs.	Over Continent Ftrs.	Middle East A'crft.	Far East A'crft.
Feb. 15	0	0	1	5	0
,, 16	0	2	0	4	0
,, 17	0	2	0	6	0
,, 18	0	1	0	0	0
,, 19	0	0	0	0	0
,, 20	0	0	1	0	0
,, 21	0	3	0	3	0
	0	8	2	18	0

Totals: North, 3,270; Middle East, about 974; Far East, 26

BEHIND THE LINES

Service and Industrial News from the Inside of Axis and Enemy-occupied Countries

Oil Thirst

THE Italian Ministry of Corporations has commenced drilling operations at Patos, Albania. A sum of 20 million lire has been granted to the Italian Petroleum Institute ("A.G.P.") which is in charge of the new venture.

Nazi Injection

RECENT models of the Bramo 323 "Fafnir" "YM" are equipped with fuel injection in place of the previous Pallas carburettor. These types are on the variation of the "Fafnir" and are said to have a H.P. of 775 and 1,000.

Italy's Aluminium

STRENUOUS efforts to increase the production of aluminium in Italy resulted in an output of 50,000 metric tons during 1941. Although this figure presents a net increase of 10,000 tons over the 1940 results, it sounds as though it almost reaches the peak capacity of Italy's production resources.

Austrian Expansion

THE Austrian firm of Steyr-Daimler-Puch, well known for its small arms, cars and bicycles, is now a part of the Goering armament combine. The firm seems to have been entrusted with the administration and production of aircraft firms "taken over" in occupied Poland, and has also expanded its activities to Switzerland. The Swiss branch, the Steyr-Solouthurn-Waffen A.G., has its headquarters in Zurich.

Studies in "g"?

THE Aviation Medicine Research Committee in Italy is being enlarged and the scope of its studies extended. The Italian Government has appointed the following experts to act on this Committee for a period of three years:—Prof. Dante De Blasi, member of the Royal Italian Academy and Chief of the Institute of Hygiene of the Rome University; Prof. G. Bastianelli, Lecturer in medical chemistry and pathology at the same University; F. Agostino Gemelli, Dean and Professor of the Catholic University of Milan, and Prof. A. Malan, Chief of the Otho-Laryngological Clinic of the University of Turin.

Focke-Wulf Comfort

SINCE a short-range reconnaissance aircraft has to be employed at frequent intervals and in close co-operation with the ground forces, the comfort of the crew and the easy operation of instruments and arms are of great importance. The cabin arrangements of the Focke-Wulf Fw189 are therefore of special interest.

The guiding idea of the designer was to give the crew of three the best possible visibility. The pilot, seated on the left-hand side, has in front of him the usual arrangement of flight instruments, and also controls the fixed machine guns. The observer's seat, on the right of the pilot, slides on rails, enabling easy access to the inbuilt cameras and arms.

From the forward position the automatic camera is within his easy reach; from the rearmost position (by turning through 90 degrees) the observer can comfortably handle the wireless set placed behind the pilot's seat as well as operate a mobile machine gun. The third member of the crew, who acts as gunner, operates the rear gun.

Exhaust heating is supplied to the cabin and to the leading edge of the wing. Another arrangement is a special protection of the cabin against the blinding effects of searchlights and sun reflections.

What Jerry Thinks

WHILE in this country many people who remember the much-promised air offensive against Germany are puzzled by the slackening of R.A.F raids, the psychological effect on the Germans, if different, is even more serious. The reduced intensity of R.A.F. raids has given the Nazis an excellent opportunity to spread the idea of British weakness and for bolstering up their morale.

The German Press criticises and ridicules this slackening of British raids. Thus, in *Luftwissen* of December, 1941, we find the following comments: "British air activity which was intensified after the spring of 1941 has so slackened since October that the winter phase of the campaign may be considered as concluded. The non-stop offensive which the British people were promised became nothing but a nuisance offensive. Bad weather conditions can hardly account for this slackening of R.A.F. bombing raids, since, for day raids, bad weather is rather favourable. Indeed, the much-advertised British Non-stop Offensive has become, with the beginning of the winter, a modest air activity which was known from last winter.

"Apart from the despatch of 'symbolic' fighter squadrons to Russia, the R.A.F. have more or less limited their day activity to attacks in the Channel area with limited and occasional penetration inland. At night, although the frequency and disposition of the British raids was not intensified, a higher average number of bombers was employed.

"In the month of the strongest raids against Germany and occupied territories, the bomb load dropped was not much higher than that dropped by the *Luftwaffe* over the United Kingdom during two or three nights of mass attacks.

"It is quite ridiculous to imagine," concludes the German periodical, "that with the vast territory of the Reich and the dispersal of its industry, the reduced intensity of R.A.F. bombing has crippled the German war production or achieved mastery of the air in the Channel area." The Germans, however, do not explain the slackening of their own raids on Britain.

Fiat RS 14 Seaplane Bomber. Powered with two Fiat A 74 engines of 840 h.p. each. Span 62.3ft.; length 43ft.; Surface 538 sq. ft.

THE THREE-SERVICES PROBLEM

Need for Unity of Command : Should the Army Have its Own Air Arm? : Basic Functions of the Royal Air Force

By MAJOR F. A. de V. ROBERTSON, V.D.

THE present war is the first one in which Britain has engaged under the system of three fighting Services. That system also obtains in two of the countries opposed to her, Germany and Italy. It does not exist in the cases of two other major combatants, the United States and Japan. The Royal Air Force certainly came into existence in the spring of 1918, but as the last war only went on for another seven months there was no time in which to test out the new system. It made comparatively little difference to the final stages of the campaign. The old squadrons of the Royal Flying Corps continued to work for the Army as they had been doing for the previous three years. The few fighter squadrons of the Royal Naval Air Service which had been lent to the Army just carried on the same work in a different uniform, and perhaps felt that their position had been regularised. The flying-boat squadrons maintained their reconnaissance round the coasts for the benefit of the Royal Navy. The only outward and visible sign that a new Service had come into being was the episode of the Independent Air Force, which indulged in strategic bombing of German production in the Rhineland towns. Actually its bombers did little damage, and though they caused the withdrawal of some German fighter squadrons to protect those towns, it has been urged that it was a mistake to deprive the Army of so many bombers at the time when the Germans were making their last despairing assault on Gough's Fifth Army. Only later was the principle enunciated that when a critical battle is in progress the strategic use of aircraft ought to be subordinated to their tactical employment—though some French Generals showed an appreciation of the principle even then.

Probably few people at the time could have given any clear reason why the British formed a third Service, except to simplify the problems of supply. The country's air effort had been hampered by the rivalry of the Admiralty and the War Office to get more and better aircraft for the R.N.A.S. and the R.F.C. respectively. It occurred to nobody at the time that the wisest innovation would have been to form a Royal Air Force, but at the same time to leave both the Navy and the Army with their respective air arms. Logic has obliged us to retrace our steps in the case of the Navy, and whether to do the same for the Army is now a very lively question.

A Haunting Dread

From the very beginning the discussion has been tainted by acrimony, and too often arguments have shown evidence of partisanship rather than of calm consideration of the interests of national defence. At the beginning the Admiralty and War Office could see no reason for having an Air Force at all, and the Air Ministry started on its way haunted by the dread of its own abolition. Long before September 3rd, 1939, there had ceased to be any substance in that fear, and now there is less cause than ever for entertaining it. Yet the reaction to that apprehension remains in the abhorrence shown by the Air Ministry to the idea that any body or person other than itself should have command over any air squadrons.

It is not easy to learn lessons from the early stages of a war in which one side started fully prepared and the other very much unprepared. Lord Trenchard, in a very long letter to *The Times*, recently pointed out that the *Luftwaffe* is not under the command of the German Army, and that Germany has won her great successes under the system of dual command. He added that in the Libyan campaigns no fault could be found with the co-operation between the British Army and the R.A.F. From these instances he undoubtedly concludes that unity of command of an operation is not necessary, and it is common knowledge that he thinks unity of command in the air more desirable. One may, however, question whether that is the right conclusion to draw from the facts which he has adduced.

Others have pointed to our various set-backs, in Norway, in France, in Greece, in Crete, and in the Pacific, in all of which shortage of air power or of some particular class of aircraft played a major part, and from these cases have drawn the conclusion that our organisation is all wrong. To such arguments the Air Ministry makes the perfectly valid reply that it would have provided more aircraft during the peace years if successive Governments had not forbidden it to do so. Even so, one rather doubts if it ever gave sufficient consideration to the needs of the Army Perhaps the War Office itself was to blame in not insisting on contingents of fighters and bombers being allocated to its use in the years of peace. It may fairly be said that the War Office has not been sufficiently air-minded or the Air Ministry sufficiently army-minded.

Combined Training Necessary

The German successes on land have been due to the perfect unanimity with which the *Luftwaffe* and the Army have worked together. Much of the recent Russian successes has been due to the same cause. In both cases there have been years of thorough combined training. Both the Germans and the Russians have realised that the air is one of an army's major weapons, and that victory on land is not possible if an army is not adequately supplied with that weapon. The same, of course, is true of an army not adequately provided with tanks or artillery or any other essential weapon. The inability of the British Empire to provide adequate air components for any of its land forces, except in Libya and Syria, has resulted in a tendency for many people to conclude that the air is the one all-important weapon. That is not a justifiable conclusion from the data. At the same time, it must be admitted that the school of thought which believes success to be possible under dual control receives support from the German record, but it must not be overlooked that long, careful, intensive training in working together was mainly responsible for the German successes.

But, it may be urged, the R.A.F. had not had that long training with the Army (it certainly has not) and yet the two have worked together satisfactorily in Libya. It is not yet certain that future military historians will fully endorse that theory. The R.A.F. in the recent Libyan battles has deliberately concentrated on attacking the German supplies. This was undoubtedly the best work which it could do, even though it is evident that its best efforts have not prevented Rommel from getting up sufficient supplies to keep on fighting. It does not seem from the reports that our aircraft have intervened to any great extent in the actual fighting. Here we seem to see again the results of past years. Special types of aircraft are needed for giving tactical help in a battle. Everyone has heard of the use made of dive-bombers by the Germans. Now there is need of a new class, which has been given the inelegant title of "tank-buster." The Germans had the classes of aircraft which they considered necessary all ready and trained before they went to war. It may be the case (we hope it is) that the American Army Air Forces are also well provided in that respect, because an "Attack" section has long been part of their forces, and has doubtless studied the subject with care. The only aspect of army work to which the R.A.F. has given careful attention in the inter-war years has been tactical reconnaissance.

THE THREE SERVICES PROBLEM

The squadrons which were called "Army Co-operation Squadrons" were very carefully and efficiently trained in that class of work, but their title was unfortunate because it suggested to the lay mind that the R.A.F. had made complete preparations for helping the Army, which was far from being the case. We invaded Cyrenaica without having provided special "attack" aircraft—perhaps also without sufficient heavy tanks, but that is another story. It seems that some types of "tank-busters" have lately been reaching Libya, but that does not acquit the Air Ministry of the charge that in the past it has not been sufficiently army-minded.

The point on which the public would like assurance is the steps now in hand to remedy our shortcomings of the past. Almost immediately after the evacuation from Dunkerque the Air Ministry, after consultation with the War Office, formed an Army Co-operation Command in the R.A.F., which was designed to remedy all past defects and to assure to the Army full air support in the future. It would maintain the separate command of all air units, but would obviate all the drawbacks inherent in that system. Since that announcement was made practically no information has been released about the new Command and its work. The public has no means of judging if all is going well and if the future is bright, or the reverse. There is small wonder that the public is disquieted, and that eminent retired officers of all the Services should engage in lengthy letters to the Press on the subject.

The tendency for the future is indicated by the appointment of Gen. Wavell. He has been placed in supreme command of all naval, military, and air forces of the United Nations in the south-western Pacific. There we get unity of command in the highest degree. It is an unprecedented appointment, but it will surely not be the last of its kind. Of course, General Wavell, a soldier, will not attempt to tell the Dutch Admiral how to handle his ships, and he will not decide the tactical details of how the united aircraft should attain their objects. The handling of both major and minor tactics must be left to the experts of the various Services. But the supreme commander will see to it that no one of the three Services attempts to win the war on its own, regardless of the operations of the other two.

A Suggestion

If one endeavours to draw up a scheme for the logical organisation of the three fighting Services in Great Britain, something like the following picture comes before the eye. The Air Ministry must first and foremost be responsible for the air defence of Great Britain. The Fighter Command should include not only the squadrons of short-range fighter aircraft (which must always have a performance superior to that of long-range fighters), the Balloon Barrage, and the Royal Observer Corps, but also the anti-aircraft batteries and the searchlights. The R.A.F. must also maintain a force suitable for strategic bombing, which would naturally include long-range fighters. Incidentally, we may hope that never again will it be necessary to send short-range fighters in sweeps over any part of France. The Air Ministry should also maintain a force (not necessarily completely separate from the strategic bombing force) as a flexible reserve to reinforce either the Navy or the Army on special occasions. Naturally, the Air Ministry should also be in charge of meteorology, design of aircraft, ordering of aircraft (when no Ministry of Aircraft Production is in operation), and of elementary flying training.

The Admiralty should be in charge (as at present) of ship-borne aircraft, of shore-based aircraft which work entirely with the Navy, and of special naval flying training.

In the absence of information about the doings of the Army Co-operation Command, it is less easy to lay down the ideal organisation for the air side of the Army. At the very least, the tactical reconnaissance squadrons (now known as Army Co-operation Squadrons) should be handed over entirely to the Army, and should be flown by Army pilots and maintained by Army technicians. It also seems that the Army ought to develop an "Attack" branch, equipped with special types of aircraft which would probably be almost useless for anything but Army work. These, too, should be completely under Army control, and should be flown and maintained by soldiers. Over and above these two classes, the Army needs long-range aircraft for strategical reconnaissance, bombers which can identify and attack tactical military objectives, and defensive fighters. Whether these three last classes can be satisfactorily supplied by the R.A.F. Army Co-operation Command, or whether they ought to be integral parts of the Army must for the present remain an open question. Certainly a definite minimum should be allotted to the Army, which would have first call upon them. When the Army is standing on the defensive, as it is at present in Great Britain, these bombers and fighters ought to be lent to the R.A.F. or to the Naval Air Service, just as squadrons of naval T.S.R. machines have been lent to the Coastal Command when they were not needed on carriers.

The Army's Air Needs

At present the Air Force lends to the Army when the latter has need and when the former can spare the squadrons. The Air Ministry is even able to boast of generosity on some occasions—e.g., from May 10th, 1940, till after Dunkerque, Fighter Command lost one-quarter of its first-line pilots. Yet the Army never had enough fighters for its needs. The root of the trouble is that the R.A.F. insists that the whole pool must remain in its hands, and that it will therefore be able to supply squadrons to the Army as needed. But, to take the case of fighters, the R.A.F. had really only got enough squadrons to defend this country, and had to overwork those which it had. One must ask whether the position would not have been less parlous if, in the inter-war years, the Air Force had demanded from the Treasury the squadrons necessary for home defence, while the Army had demanded an adequate Air Component over and above the needs of home defence. The Treasury might have demurred, but at least the position would have been made clear. As things were, everybody was taken by surprise.

The Air Ministry takes the point of view that it would be wasteful to let the Army have its own fighters and bombers while it is guarding the coast of Britain, assuming that in that case the squadrons would be kept aground. When the invasion comes, says the Air Ministry, then we will help the Army. But certain squadrons need constant practice with the Army in manœuvres, and when they are not so required they could be lent to the Air Force. It would be far better for the Army to be the lender than to be the borrower. That applies whether the squadrons in question wear khaki or blue uniform, though it would be the natural thing to put them into khaki.

One considerable advantage of such a common-sense organisation of our air power would be the effect which it would have on the Treasury in the coming days of peace. There is sure to be a reduction of armaments—that is only natural and right—and there may some day be a Pacifist Government in power again which will want to economise on the Estimates of all three fighting Services. When all air squadrons were borne on the Air Estimates, the Air Ministry had to do the best it could with its allotment, and, not unnaturally, it economised on the provision made for Army needs. In the same way the War Office economised on anti-aircraft defence. If in the future the Air Ministry is in a position to declare that it must have such and such a minimum of A.A. guns and searchlights, while at the same time the War Office can stipulate for a certain minimum air strength, the Treasury will find it much more difficult to resist the demands. In that way, even with reduced forces, we may achieve a sound distribution of our air strength, and avoid sending expeditionary forces again overseas without a due proportion of suitable aircraft.

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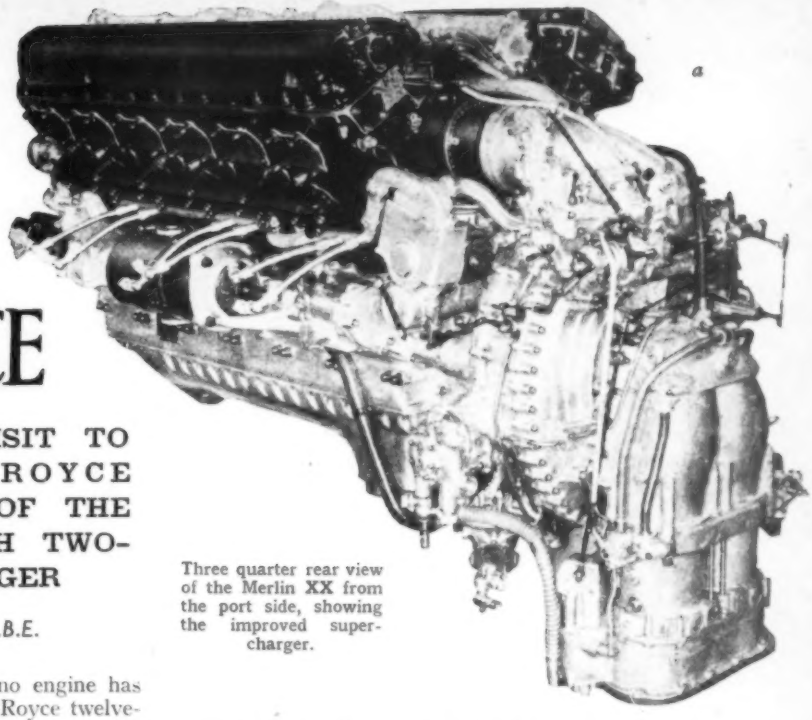
IMPRESSIONS OF A VISIT TO VARIOUS ROLLS-ROYCE FACTORIES. DETAILS OF THE NEW MERLIN XX WITH TWO-SPEED SUPERCHARGER

By G. GEOFFREY SMITH, M.B.E.



Three quarter rear view of the Merlin XX from the port side, showing the improved supercharger.

IN the world of aircraft engineering, no engine has acquired greater fame than the Rolls-Royce twelve-cylinder V-type liquid-cooled Merlin.

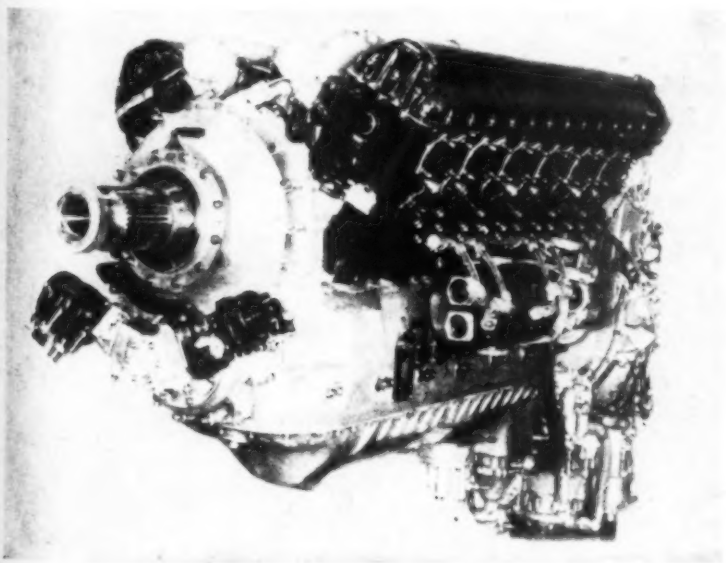
Lucky it was that this country possessed at the outbreak of war an engine so powerful and so wonderfully developed that it has remained in its basic form to this day, the unchallenged leader of the world in the liquid-cooled class. The reminder is deserved rather than needed that we largely owe to the existence of the Rolls-Royce Merlin the wonderful success of the R.A.F. in the Battle of Britain in the autumn of 1940. The importance of that victory at a critical juncture of the war will be appreciated the more as time rolls on.

Some ten years ago the company realised that it would be necessary to produce a new engine to take the place of the Rolls-Royce Kestrel which was in production at that time, and they decided in November, 1932, to go ahead with the design of an engine of about 27-litres capacity. This engine materialised in the form of the world-famous Rolls-Royce Merlin, and ever since the process of development by research, experiment and concentration upon details has continued and resulted in a continuous increase of power available. So far-seeing and gifted were the designers in evolving the original design that the successive types up to the latest and far more powerful Merlin XX to which these notes primarily refer, remain substantially the same. Even the crankshaft and bearings, the pistons, cylinder blocks, crankcases, are basically the same as in the original conception, though naturally innumerable detail improvements have been effected as constant study and experiment and metallurgical improvements have made possible.

Benefits of Concentration

The effect of such amazing foresight in planning the entire engine with such a reserve to provide for future developments and power increases will not be lost upon the engineering world. Not only has it meant that progress could be concentrated upon this single design, and maintained as a continuous progressive policy but, equally important, that the Royal Air Force maintenance service has been simplified beyond all measure. For example, rocker gear as well as the general mechanism of the later types are dimensionally the same and, therefore, interchangeable with the original Merlin II, so that the problem of stores and spares in scattered establishments, always a major consideration in the field, has been appreciably eased.

One may go further in instancing the benefits accruing from the retention of a given type over a long period. Not only is it possible for the development and experimental staffs to centre upon their task of extracting greater power and enhanced qualities of endurance from a type the whims and idiosyncrasies of which are familiar and well understood, but also in the workshops the benefits arising from concentration upon a standardised basic design are incalculably great. Thus, components which originally entailed 100 man-hours in production for example, can be, and indeed have been, reduced to a fifth of that figure by expert study of production technique and the introduction of specialised plant which is facilitated by a big demand for particular parts. Quite obviously, repetition work is of enormous help to the production engineer since it makes possible the installation of special equipment for a given part entailing intricate operations, and the planning of a production technique



Merlin XX engine—threequarter front view from the port side.

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which in the aggregate means perhaps six engines in place of one produced by piecemeal methods.

This point is especially stressed for other reasons. For example, there is frequently a wrong conception of what the term "modification" implies. All too often the notion prevails that modifications are something to be avoided like the plague, spelling delay and hold-ups, but this is more often than not a complete fallacy; a modification can, and often does, prove beneficial. It has been my privilege at Rolls-Royce invitation and with Ministry of Aircraft Production approval to visit their huge engine factories, and manifesting itself more than anything else is the evidence of constantly improving manufacturing technique, hand-in-hand with increasing B.H.P. mainly as a result of expert collaboration between the production and design departments—a highly desirable state of affairs and one for which I have pleaded repeatedly in articles in *Flight* and *Aircraft Production*, and, indeed, since my R.A.F. days when serving in the Engine Production Department of the Air Ministry in the Great War.

Designing for Production

In years gone by there has been a tendency to accord to designers too much unbridled sway—let us confess it whether we are thinking of aircraft, automobile, or any other branch of engineering. No superman can be expert in every sphere of engineering. And yet obvious though the fact may be, we could all quote cases in which either due to a lack of practical workshop knowledge or a failure to collaborate as closely with production personnel as the need demanded, designs have been introduced demanding slow, laborious and costly machining processes. Often the necessary special tools have not even been available.

This is most certainly not the case in Rolls-Royce works. To-day, and for long past, the practice has been for the chief production engineer, who maintains close contact with departmental heads, to encourage suggestions for modifications in the design to simplify production processes and assembly. With a progressive spirit of advancement these suggestions are passed on and considered promptly by the designing staff, and if they are acceptable from the engineering aspect, approval is at once forthcoming, and a new sequence of manufacturing operations introduced.

To quote a case in point as applied to foundry work (and here the reader will need no reminder that the lightweight Merlin engine embodies many intricate castings of aluminium alloy and efficient foundry work is an all-important phase of production), it has been usual hitherto for R.-R. engines to embody joints with flanges on the inside. Study of the difficulties of the foundryman in extracting the pattern from the mould indicated that time would be saved and the risk of breaking the sand reduced if the inside were left flush and the flange changed to the outside edge. The recommendation was made, the modification accepted, and a speeding-up of production achieved. A case of practice making perfect. But one could quote many other instances of improved rate of output due to reduced machining operations or amended design by this willing and expert collaboration between production chiefs of the various work of this important group.

This collaboration may perhaps give a new complexion to the much abused term "modification" and what it has all too often implied quite erroneously. In short, it often spells better performance, and improved speed in manufacture, rather than delay. This particular contact work to achieve accelerated production is largely carried out by brilliant young engineers working under the encouragement and guidance of long-service Rolls-Royce engineers whose names are (or should be) household words.

And what pleased the writer in investigating this aspect of the subject was the appreciation shown on the one hand by the production engineer of the assistance received from the foundry engineer; and later when touring the foundry with that worthy, the corresponding satisfaction displayed at the readiness with which his recommendations are received by the production engineer for consideration and eventual adoption.

By and large this process of eliminating complexities in the Merlin engine has resulted in many hundreds of man-hours being saved per unit, and the total output so speeded up that each week hundreds of engines emerge from the several great magnificently planned and equipped factories in the Midlands, in the North and in the West. These factories will long remain as a monumental testimony to the foresight of those who evolved the Government shadow factory scheme and entrusted the management to the parent aircraft firms.

From this general discourse on the works angle, we may pass to the latest example of the Rolls-Royce aircraft engine, the Merlin XX and its feature of design.

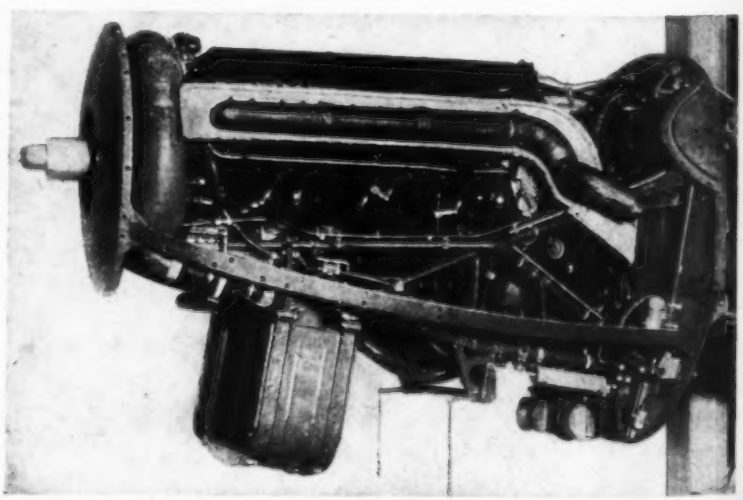
The increase in the power output of the new engine can be ascribed mainly to research and improvements in the supercharger design and to the development of high octane fuels which permit the use of higher boosts and cylinder operational pressures.

Modern aircraft engines are completely self-contained units with the radiator subsidising an oil cooler, an automatically controlled cooling system, and incorporating an auxiliary gear box and all necessary pipes and electrical wiring forward of the bulkhead. Thus the task of installation has been greatly simplified. The complete power unit may be removed or the engine and its mounting alone disturbed leaving the bulkhead in position with the auxiliary drive gear box and aircraft impedimenta *in situ*. Interchange of engines may thus be readily effected.

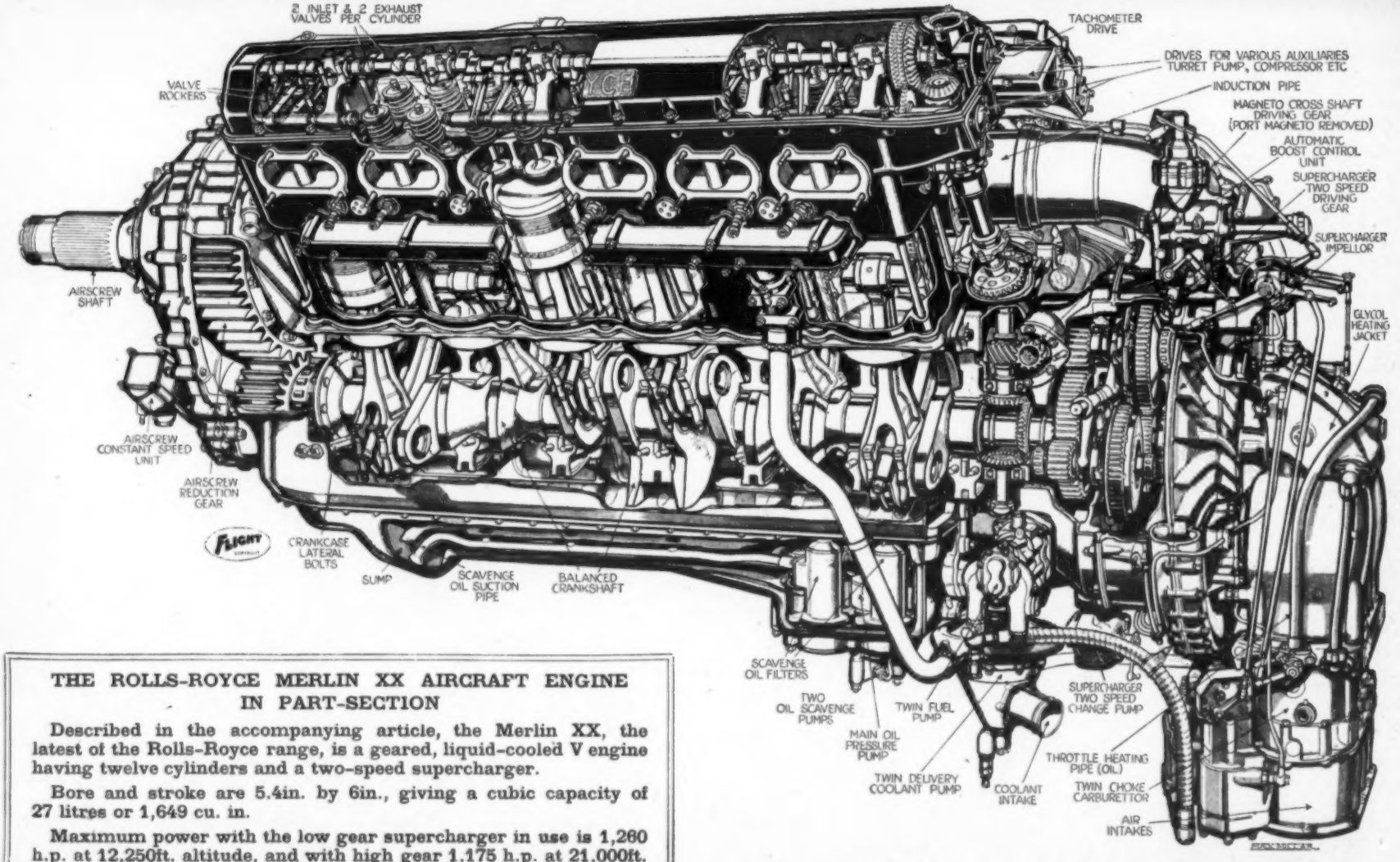
Minimum Frontal Area

The great attraction of the V-type liquid-cooled engine is the small frontal area it presents, enabling the use of a minimum section of fuselage. This attribute is particularly appealing in fighter design, in addition to the improved vision that it provides for the pilot in single-engined types. A point in favour of liquid-cooled engines, too, is their ability to operate at very high boost pressures when emergency demands such a course.

As already indicated the Merlin XX now in service follows basically the lines and characteristics of its forerunners. It has twelve cylinders arranged V-fashion at an



Typical Merlin XX power plant installation with its cowling removed.



THE ROLLS-ROYCE MERLIN XX AIRCRAFT ENGINE IN PART-SECTION

Described in the accompanying article, the Merlin XX, the latest of the Rolls-Royce range, is a geared, liquid-cooled V engine having twelve cylinders and a two-speed supercharger.

Bore and stroke are 5.4in. by 6in., giving a cubic capacity of 27 litres or 1,649 cu. in.

Maximum power with the low gear supercharger in use is 1,260 h.p. at 12,250ft. altitude, and with high gear 1,175 h.p. at 21,000ft.

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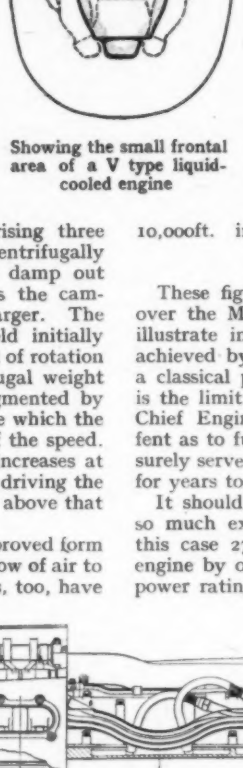
angle of 60 deg., the bore and stroke being 5.4in. × 6in. respectively, giving a swept volume of 1,649 cubic inches. The compression ratio is 6 to 1.

A two-speed supercharger is now fitted, the low gear ratio being 8.15 to 1 and the high gear 9.49 to 1 and, as already indicated, it is primarily in the modifications and improvements to the supercharger by which the increase of power available has been achieved. It is of the high-speed centrifugal type embodying an impeller which is driven from the rear end of the crankshaft through a two-speed gear, the high gear being normally engaged above 6,000ft. To relieve the gear teeth from the exceptional loads which result from impeller inertia (their respective rotational speeds are 21,597 and 25,148 r.p.m.) following sudden acceleration and deceleration of the engine, a spring drive is incorporated consisting of a torsionally flexible shaft.



Showing the small frontal area of a V type liquid-cooled engine

The impeller inertia, in combination with the friction drive which incorporates the two-speed gear mechanism illustrated, comprising three layshaft driving spindles each embodying a centrifugally loaded clutch with Ferodo linings, serves to damp out torsional oscillation of the shaft which drives the camshaft and auxiliaries as well as the supercharger. The clutches of the two-speed mechanism are held initially in engagement by light springs, and as the speed of rotation of the crankshaft and therefore of the centrifugal weight increases, the pressure of these springs is augmented by a centrifugal force, and consequently the torque which the clutches can transmit increases as the square of the speed. As the torque required to drive the impeller increases at a somewhat similar rate, the gear is capable of driving the impeller with a predetermined margin of torque above that causing slip.

The redesigned supercharger casing has an improved form of central entry which gives a better and freer flow of air to the blower. The rotating and fixed guide vanes, too, have been amended. The rotating guide vanes are formed of steel and are matched to the rotors of R.R.56 Aluminium Alloy. The rotors are balanced separately and together to approximate to dynamic balancing on knife edges.

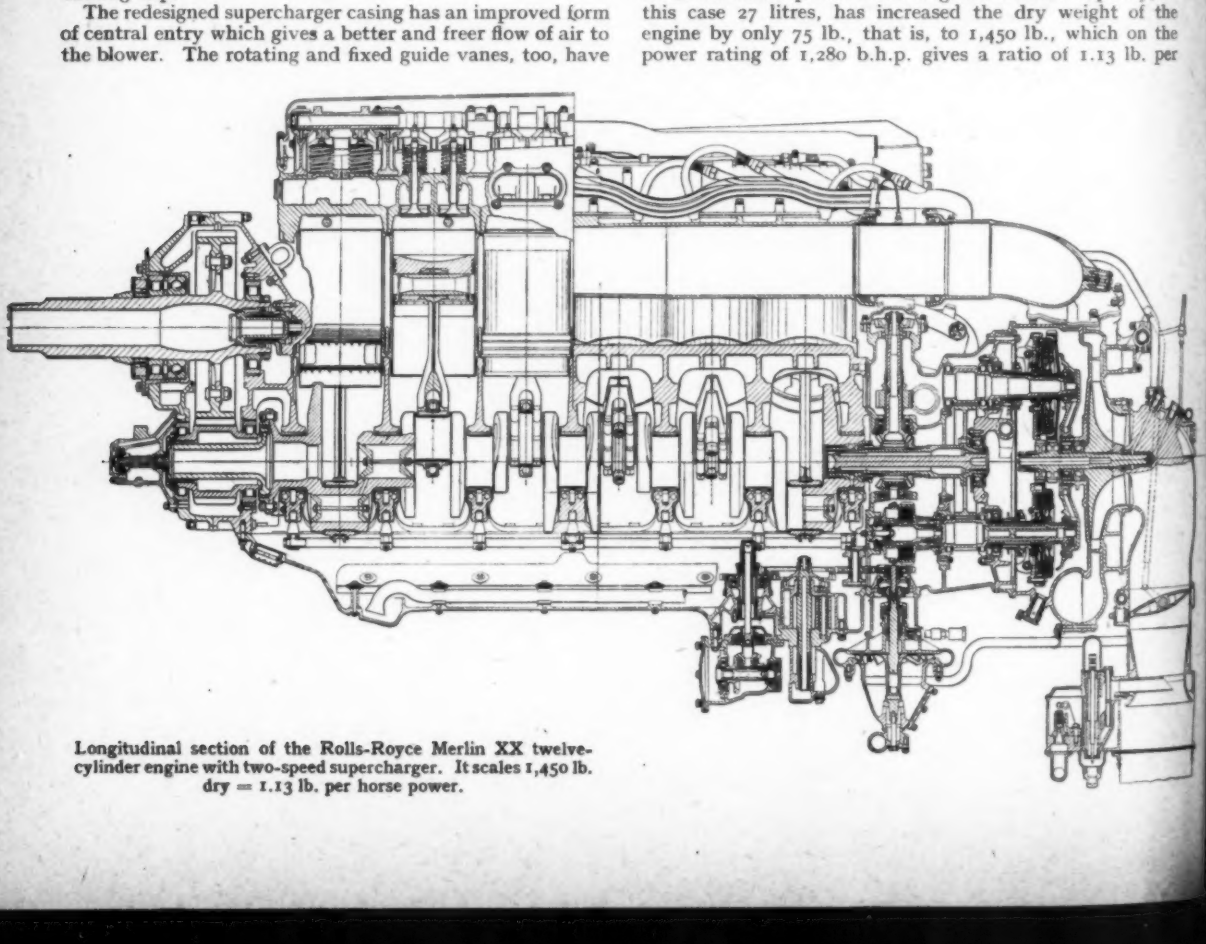
The diffuser vane ring is an aluminium die casting bolted by means of special shaped bolts to the supercharger casing. These important changes in conjunction with a larger twin-choke up-draft S.U. carburettor, designed as a complete separate unit, have resulted in a greater weight of mixture entering the cylinders and thereby a marked increase of power. Using 100-octane fuel the International Power Rating of the Merlin XX is with the low gear supercharger 1,240 h.p. at 2,850 r.p.m. at 10,000ft. and +9 lb./sq. in. boost, and 1,175 b.h.p. at 2,850 r.p.m. at 17,500ft. and +9 lb./sq. in. boost.

The rated altitude, that is, the lowest height at which full throttle is permissible at the international (climbing) r.p.m. is low gear and 18,000ft. in high gear.

Increase of 250 h.p.

These figures represent an increase of nearly 250 h.p. over the Merlin II of identical cylinder dimensions, and illustrate in a convincing manner the technical progress achieved by years of "toil, tears and sweat," to borrow a classical phrase from our worthy Prime Minister. Nor is the limit of attainment yet in sight. A talk with the Chief Engineer gave one encouragement and enlightenfent as to further far-reaching improvements which should surely serve to maintain the Merlin on its pinnacle of fame for years to come.

It should be added that the achievement of extracting so much extra power from a given cubical capacity, in this case 27 litres, has increased the dry weight of the engine by only 75 lb., that is, to 1,450 lb., which on the power rating of 1,280 b.h.p. gives a ratio of 1.13 lb. per



Longitudinal section of the Rolls-Royce Merlin XX twelve-cylinder engine with two-speed supercharger. It scales 1,450 lb. dry = 1.13 lb. per horse power.

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horse-power—the prodigious figure of over 100 b.h.p. per cylinder! And yet remarkable as those figures may seem, we have the even more amazing figures of the "R" racing type Buzzard engine to reflect upon. That engine specially developed by Rolls-Royce for the Schneider Trophy, which it won outright, gave 2,300 b.h.p. at 3,200 r.p.m. and scaled 1,630 lb. = 11 oz. per b.h.p. It was a masterpiece of precision engineering in 1931 and remains a symbol of British efficiency ten years later.

Aluminium Largely Used

The cylinder block of the Merlin is a single aluminium casting comprising the head and the coolant jacket. "Wet" cylinder liners of steel are provided which start life as a 26 lb. forging and finish up weighing 7 lb. only. The liners have shoulders which fit against the crankcase and the cylinder block at opposite ends. A coolant joint is effected around the base of each liner by means of two rubber rings fitting grooves in the liner. A joint ring of aluminium alloy is arranged between the upper shoulders of each liner and the cylinder block. The resulting joints are maintained by means of 14 long studs which extend from the crankcase through to the tops of the cylinders Except for the four end studs, the remaining ten pass through corrosion-resisting tubes which form oil return ways and make coolant joints at either end by means of rubber rings held in annular recesses in the block casting. Two main coolant pipes extend from the centrifugal pump to the rear connections of each cylinder block.

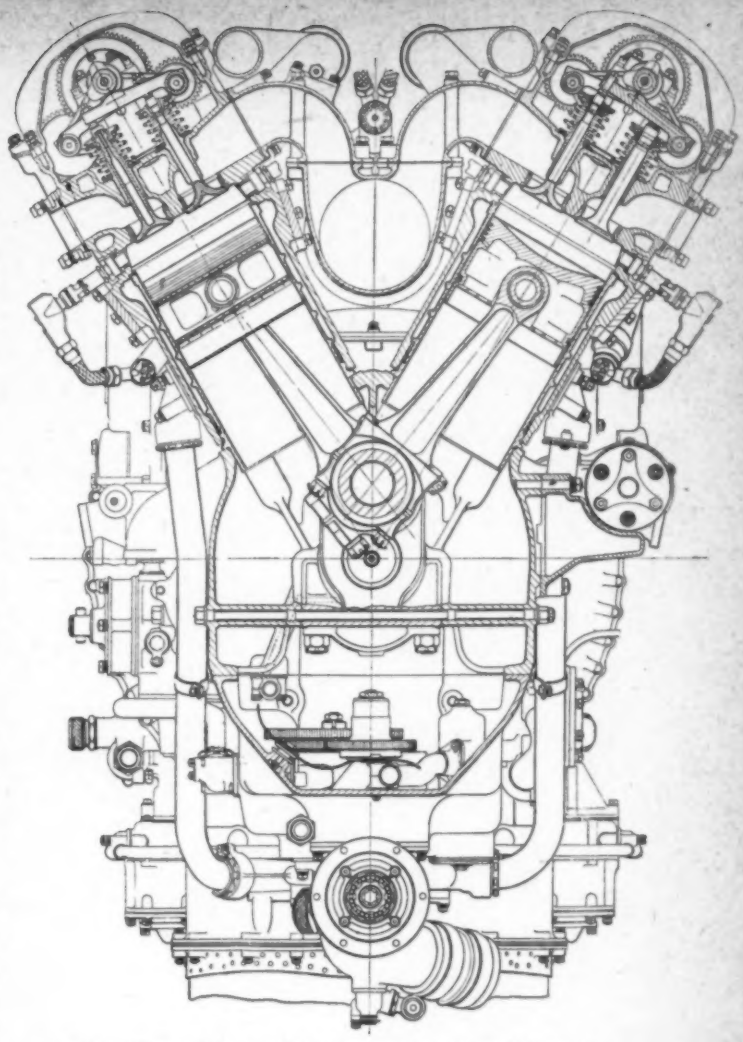
Two inlet and two exhaust valves are provided for each cylinder operated by an overhead camshaft through the medium of rockers having aluminium bush bearings. All valves are placed parallel with the centre line of the cylinders. Sodium-cooled exhaust valves are utilised operating in phosphor-bronze guides. The seatings, which are screwed into the head, are of high silicon chromium steel, and the engaging face and crown of the valves are surfaced with "Brightray." The stem tips are of Stellite. Inlet valves work in cast-iron guides and also have high-silicon chromium steel seatings. Each valve has two concentric valve springs retained by a collar and split wedge. Adjustment is effected by means of a tappet screw and lock-nut.

The camshafts are driven by inclined shafts and bevel gears from the wheelcase at the rear of the engine, and each camshaft has additional gear wheels for driving various auxiliaries.

Forged aluminium pistons are employed, having three pressure rings and two drilled scraper rings, and a hardened-steel floating gudgeon pin. Forked H-section connecting rods scale 8¼ lb. and 7½ lb. respectively in the raw state; when machined all over 2⅜ lb. and 2¼ lb. They are provided with lead bronze bearings for the crank-pin, and a floating phosphor-bronze bush is fitted in the small end.

Hollow Steel Crankshaft

The hollow crankshaft compels admiration as a supreme example of design and perfect finish. It is a one-piece forging reduced during machining from 280 lb. to a finished weight of 180 lb. At the front end there is a flange bolted to it which transmits the drive through an internally toothed annulus to a short floating roller quill shaft which drives the reduction gear pinion through internal splines at the front end. Thus the crankshaft end-bearing is insulated from loads due to the gearing. The airscrew shaft, which has a reduction of 0=420 to 1, is carried in roller bearings and a ball thrust is provided. It scales but 34½ lb. of its original 108 lb. as a forging. Lubrication is of the dry-sump system, and there are two gear-type scavenge pumps working in parallel to drain the front and rear of the lower half crankcase. The supply system comprises a main and low-pressure circuit served by a single pressure-pump.



Section through No. 5 cylinder looking towards rear of engine.

Two screened magnetos are spigoted to the wheelcase, and each is arranged to fire all twelve cylinders independently. Lodge special type sparking plugs are arranged on opposite sides of the combustion chambers. Dual gear-type fuel pumps are driven in tandem from the L.H. side of the wheelcase and deliver fuel direct to the float chambers.

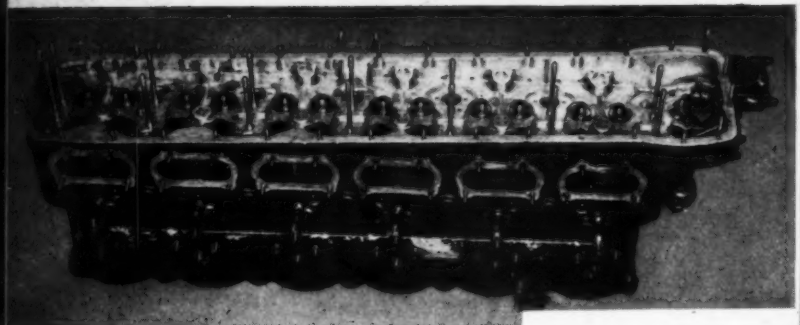
Twin Choke Updraught Carburettor

An improved type of S.U. carburettor is employed having increased diameter of chokes, and two independent float chambers with two saddle-type cork floats—one around each main diffuser well—and control the fuel inlets by needle valves. The effect of banking on fuel level has thus been reduced.

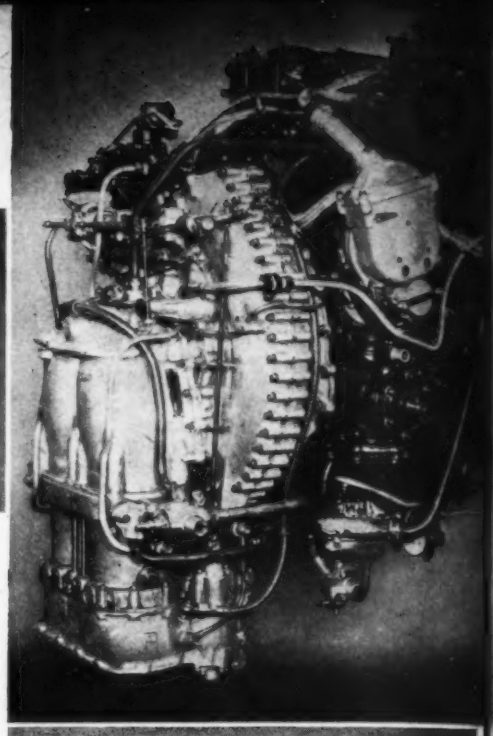
The automatic boost-regulator controls the supercharger delivery pressure by an automatic servo mechanism working through a differential linkage to limit the throttle opening and to protect the engine from damage resulting from overboosting. It is of the progressive type with the boost pressure determined by the degree of throttle opening and maintained automatically within a range determined by the altitude, this range increasing as the throttle opening is increased.

Until the rated boost pressure is reached, the boost pressure is not maintained over the whole throttle range. The regulator consists of an aneroid (balance flexible metallic bellows) which is exposed to the boost pressure. The aneroid is coupled to a piston-valve to admit boost pressure to one side or other of a relay piston which is interconnected with the throttle control. Thus the opening of the throttle is controlled to suit the intake pressure.

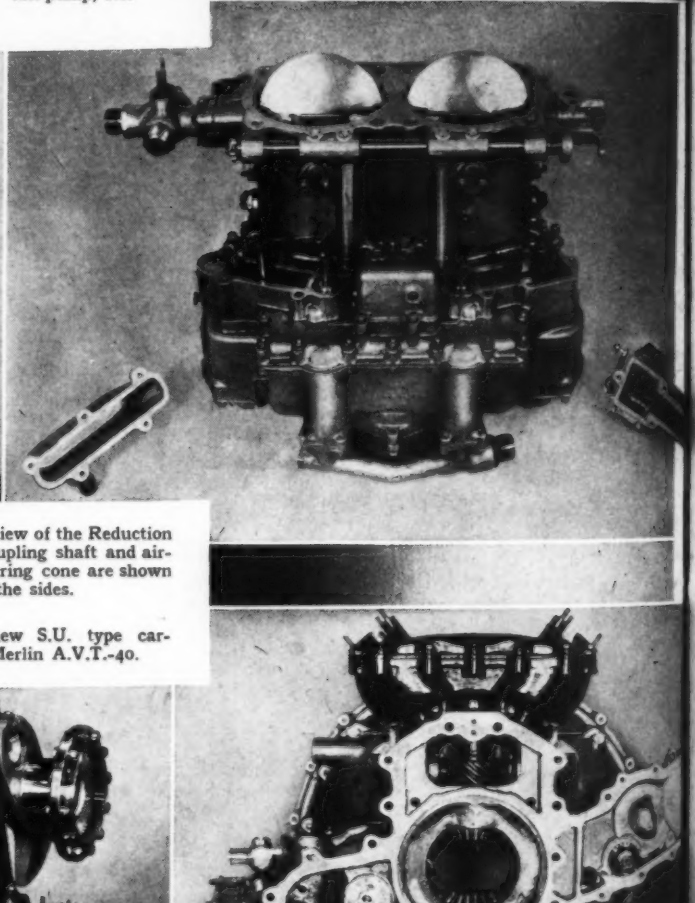
FEATURES OF THE ROLLS-ROYCE MERLIN XX.



(Above) One-piece cylinder block—exhaust side.

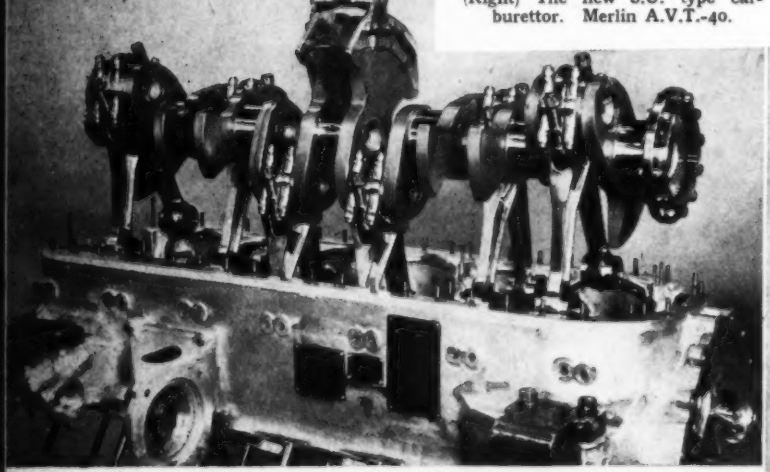


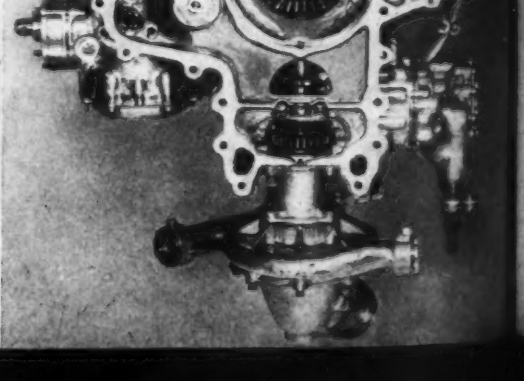
(Right) Three-quarter rear view showing supercharger assembly, controls, magneto, coolant pump, etc.



(Above) Rear view of the Reduction Gear Unit. Coupling shaft and airscrew hub centring cone are shown at the sides.

(Right) The new S.U. type carburettor. Merlin A.V.T.-40.





(Above) Crankshaft of the Merlin XX engine being lowered into upper half of crankcase during assembly.

(Right) Front view of the wheelcase of the new Merlin for auxiliary drives.

A BRITISH MASTERPIECE

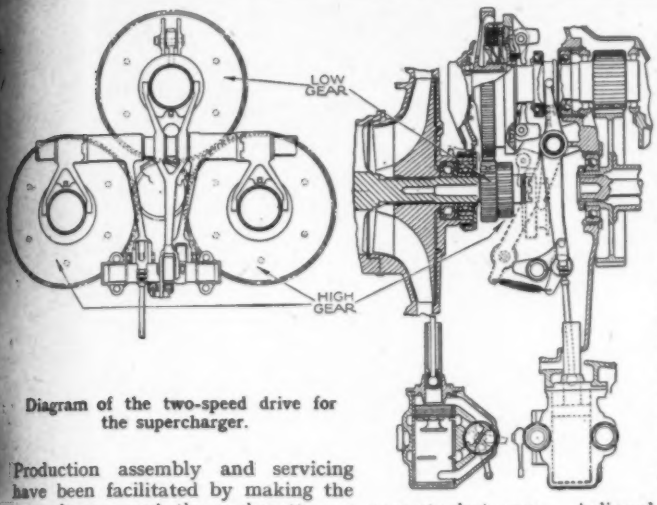


Diagram of the two-speed drive for the supercharger.

Production assembly and servicing have been facilitated by making the supercharger and the carburettor as separate but complete sub-units ready to bolt on to the engine. For starting both hand and electric gear are provided.

The increase in the operational altitude of the latest engine, as compared with its forerunners, has necessitated improved magneto performance. Intensive development was necessary to provide efficient ignition in the rarefied atmospheric conditions encountered at higher altitudes. This effect of height also reacts adversely in other ways, notably on the fuel and lubrication systems, and, as may be imagined, many problems have had to be solved in this connection. It will not be overlooked that all high-performance fighter aircraft at present in the service of the R.A.F. are powered by liquid-cooled in-line engines; similarly the fastest fighters of other nations engaged in the war are equipped with this type of engine because of the small frontal area, and thereby minimum drag.

For Twin-engined Aircraft

The clean lines of the Merlin Spitfire installation are an excellent example of the reduced frontal area presented by liquid-cooled engines, since the size of the bulkhead to which the engine installation is fixed is only 10.5 sq. ft. in area This area is not governed entirely by the size of the engine, and it has been demonstrated that, by rearrangement of various auxiliary fittings, a bulkhead as small as 8.5 sq. ft. can be utilised on twin-engined aircraft.

In the Merlin XX engine there are nearly 11,000 separate pieces. Included in this total are parts of 4,500 different varieties. Although aluminium enters very largely into the design of this lightweight engine, the total of 1,450 lb. weight is divisible as follows:—

Steel	47 per cent.
Aluminium ..	43.6 ,,
Brass and bronze	2.5 ,,
Other materials	6.9 ,,

The makers state that only 12 different classes of steel are used throughout, including special-purpose steels, one grade of cast aluminium alloy and two grades of wrought aluminium. All the aluminium is produced from the world-famous Rolls-Royce Hiduminium range of alloys developed by the Rolls-Royce Company.

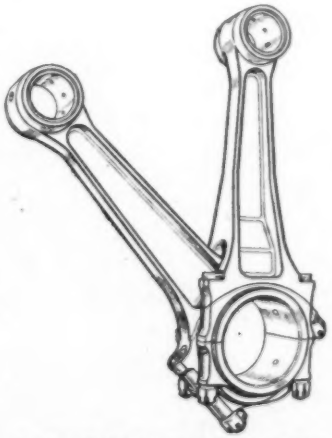
The Test Houses

The rows of test houses, a feature of the different Rolls-Royce factories, are of extremely modern design with the latest dynamometer equipment. Bright and neatly maintained control rooms, sound and vibration proof with a varied array of recording instruments, enable the testing staff to watch through the observation window the 2½-hour endurance test of engines lit up by floodlights in the adjoining test house. What a contrast to the days of escaping oil, freezing air currents and deafening noise reverberating through the body and the necessity to use ear plugs! After two hours the engines are stripped for examination, reassembled and subsequently given the final test of ½-hour duration.

The test houses are a department where male labour, perhaps naturally, is now used exclusively, but it would be an omission on the writer's part if particular mention were not made in this summary of the manufacture of the Rolls-Royce Merlin to the increasingly important part that women are playing. Just whether the skilled management, the guiding influence which carries the eventual responsibility, or the women operatives themselves, deserve the greater measure of credit, I will leave others to decide, but the proportion of women workers and the skill and dexterity of their work have to be seen to be believed. In the largest of the dispersal factories the management have built up the creditable proportion of over 50 per-cent. women labour, as well as a high percentage of unskilled workers, and remember, this is on complicated mechanism composed of the finest and most expensive materials demanding a degree of accuracy unsurpassed in any other branch of engineering. Not only in the machining and fitting shops, the metallurgical, radiological and standards rooms has this desirable state been reached. The foundry is another example of the successful employment of women operatives where their deft fingers are particularly suited and busily applied to aluminium-alloy castings of every conceivable shape, save only the largest sizes where undue fatigue might be experienced. Their work, too, is highly appraised, a common remark of the management being that they are ready and eager to learn, and are, generally speaking, more manageable when proficient in that they obey assiduously the production technique laid down. Their keen spirit and seeming pride in their work are apparent to any observer. But the particular foundry I refer to is no ordinary one. Surely nothing exists in this country to surpass it either in layout or equipment, with possibly one notable exception.

A Mechanised Foundry

It is almost completely mechanised, with progressive roller-track systems, automatic delivery of materials, reclamation methods and a remarkable sand-reconditioning plant. But so much could be said of that efficient and impressive foundry and its equipment that it must remain for the moment as a subject for special treatment.



A pair of forked H section connecting rods with lead bronze lined steel bearing shells

From the test-beds the engines are conveyed to the despatch department, where, having learned something of the "engine every hour" speed in the largest of the works, I anticipated seeing long lines of finished engines such as occasional impressive photographs portray. You will see nothing of long lines of idle aircraft engines at Rolls-Royce. As quickly as they reach the terminal point of the track with their pass tags affixed, one by one they are placed in substantial wooden cases and slung on to trucks waiting in the sidings. With a confidence born of the knowledge and conviction that they constitute a British engineering feat well and truly done, the engines are despatched for operational duty in many spheres to add lustre to the already brilliant achievements of the R.A.F. pilots who operate them.

Twenty-seventh of the Second Series

FRIEND or FOE?

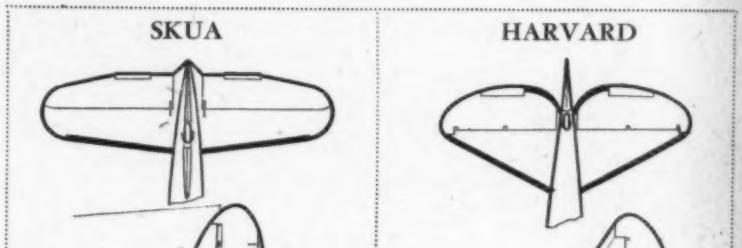
Fleet Dive-bomber and the American Trainer: Blackburn Skua and the Harvard

THE skua has been defined as a sea-bird which lives chiefly on offal, so the species provides a very appropriate name for a Fleet Air Arm dive-bomber. The Blackburn Skua and the North American Harvard trainer provide another example of two aircraft which greatly resemble each other except for their tail units. Their overall dimensions are reasonably close to each other, and the general outlines of fuselage with radial engines, low wings and tandem cockpits under similar styles of "glasshouse" all follow pretty much the same layout. But when one's eye reaches the tail of the Skua it will at once spot a distinctive characteristic which this machine shares only with its sister craft, the Blackburn Roc.

The Roc (floatplane version), readers will remember, was dealt with in the 24th article of this present series, in *Flight* of February 5th, and a comparison between the illustrations of the Skua on this page and those of the Roc will show that the fins and rudders, set well forward in relation to the tailplane, are identical on both machines. The plan and mounting of their respective tailplanes are also the same, the only small difference in the complete tail assembly lying in the fact that the Skua, with its fixed tail wheel, has a smaller stabilising fin beneath the stern of the fuselage.

The Harvard I has a straight slope to the leading-edge of the fin and a projecting rudder extended right down to the bottom line of the fuselage. The trailing-edge rises vertically from the heel but curves in to the small round apex. Incidentally, the rudder of the Harvard II differs from that of the Harvard I in that its trailing-edge makes practically a straight slope between apex and heel, giving a triangular effect very similar to that of the Defiant

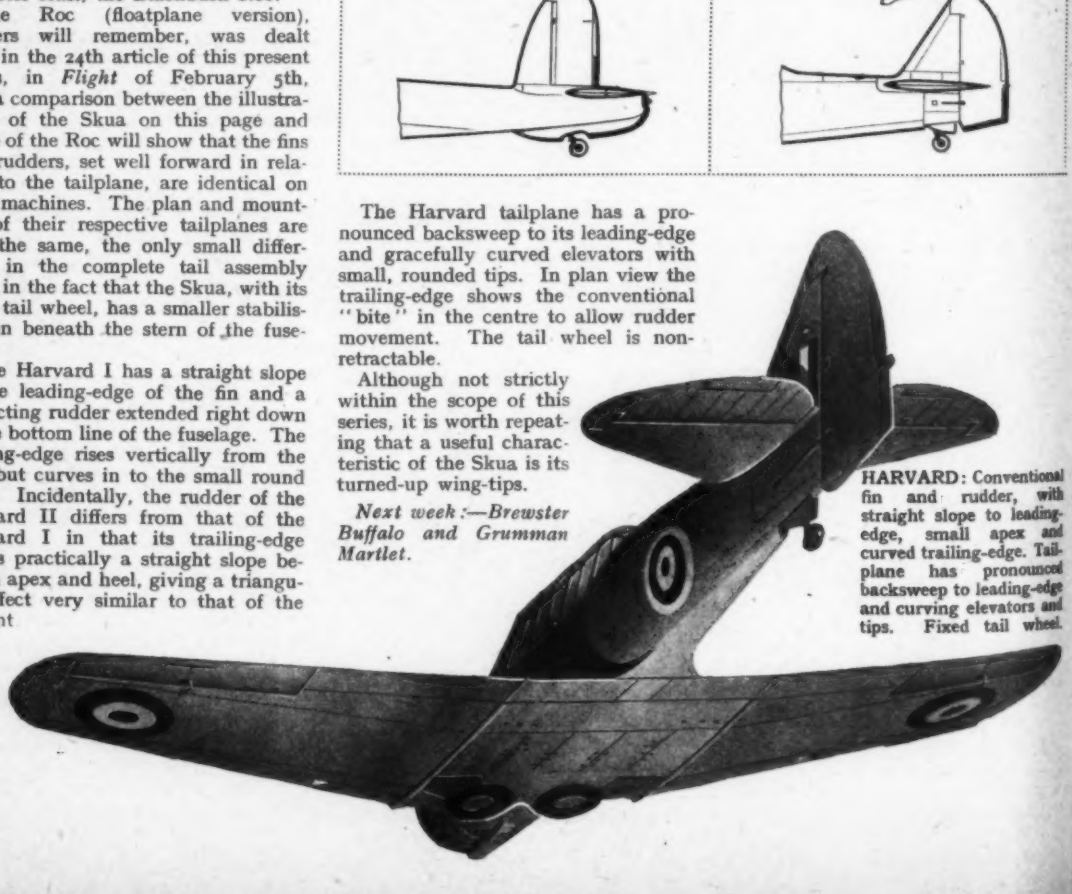
SKUA: Fin and rudder, with curved leading-edge, round apex and vertical trailing-edge, is set well forward in relation to tailplane which has slight taper on both edges and round tips. Stabilizing fin below fuselage and fixed tail wheel.



The Harvard tailplane has a pronounced backsweep to its leading-edge and gracefully curved elevators with small, rounded tips. In plan view the trailing-edge shows the conventional "bite" in the centre to allow rudder movement. The tail wheel is non-retractable.

Although not strictly within the scope of this series, it is worth repeating that a useful characteristic of the Skua is its turned-up wing-tips.

Next week:—Brewster Buffalo and Grumman Martlet.



HARVARD: Conventional fin and rudder, with straight slope to leading-edge, small apex and curved trailing-edge. Tailplane has pronounced backsweep to leading-edge and curving elevators and tips. Fixed tail wheel.

Topics of the Day

IGNORANCE IS NOT BLISS

"Indicator" Discusses the Unified Command Idea and Considers the End of All This

At one time, and long before this war started, one or two of the daily papers ran a prolonged "let youth be served" series of features. There was, at the time, quite a strong general idea that everything would go a great deal better if all the important jobs in the world were held by young men and young women of 30 years of age or less. I think that this sort of loose thinking annoyed "Youth" at least as much as, and probably more than, it annoyed the older people who felt that they deserved to hold the reins of industry and what-not.

The average young persons are certainly not experienced enough or sufficiently sure of their own decisions to take on important jobs—though they can hold their own for a time, until they are found wanting. At about the same period one of the newspapers, I believe, carried out a vast Blitz on itself, and was newly staffed by a mass of young and extremely enthusiastic, but somewhat overcome young people who proceeded to make it a most "advanced" and exciting, but quite unreliable journal. When it came to the point, the youngsters couldn't make the long-range grade; they rushed into print and talked volubly about this and that, without regard to the facts.

Newspaper Howlers

It seems to be true—with one or two marked exceptions—that whenever an ordinary journal starts to talk about specialised subjects it makes the most frightful bloomers, but these bloomers are, of course, only noticed by the very tongue-tied few who can't be bothered to answer back, and the howlers remain unhowled-down. Of course, the specialists lose heart; they feel that if the paper in question is so inaccurate about *their* subject, then it is reasonable to suppose that it is equally inaccurate about everything else. The fault does not apply to newspapers only. Until the war, a greater proportion of people must have been more ignorant and consistently ill-informed about aviation than they were about any other subject. Most extraordinary errors were made and passed over by the great journals and by writers who should have known a good deal better.

Unfortunately, this colossal ignorance is not confined to the ordinary person, and this fact has always seemed to me to be the most powerful argument in favour of a separate Air Force. The men whose wholetime job it has been to deal with men, tanks, and battleships may quite reasonably be expected to ask impossibilities of its air arm. I'm not at all sure that the Germans themselves haven't suffered from the effects of this ignorance. In a general way it has been nice for their High Command to be able to call on masses of dive-bombers just when they needed them, but it may also explain their losses. No doubt the aforesaid H.C. engineered the initial raids on this country by daylight; the *Luftwaffe* chiefs must have known that the losses would be crippling, but they had to go ahead in preparation for a vast land and sea assault. Possibly the H.C. banked on more air support during the winter in Russia; they were not to know anything much about the difficulties involved in operations during intense cold—the engines which can't be started, the ground crews who cannot work, and the aircraft which cannot even take off until runways have been cleared. The H.C. imagined that it would only be necessary to order machines into the air and, hey presto, they *would* be in the air.

No, I don't much believe in a unified command, though it is none of my business to say so. My very little experience in peace and war of walking military persons about airfields gives me a bias against the idea. I would myself hate to feel that my life and future were in the hands of someone who knew next to nothing about my job. Of course, decisions would be taken between the chiefs of the two or three fighting services in use during any particular operation, but if the operations were on land, then the military chiefs would have the final say, and if over sea then the naval chief would have one more ring and might be able to browbeat the commander of the air support.

Perhaps more important still, the people in this country have confidence in the Air Force and the Navy, but not so very much confidence in the Army. The latter have always been forgiven for failing to win all the time against impossible odds, and the majority of the ordinary people are very sorry indeed that the Army has hardly yet been given a chance to show what it can do. But the Army chiefs have not yet been forgiven for being old-fashioned in their ideas of arms and armaments.

Now that it is all ancient history and the whole picture is different, I cannot be hauled over the coals for saying that I met an Army officer soon after the collapse of France who told me that he had had innumerable arguments with his superior officers about the possible type and strength of the enemy's armoured divisions. He was apparently told to mind his own business and informed that, on the best possible authority, the Germans had no tanks worth talking about. That, in fact, there was nothing to worry about. Meanwhile, this officer's own crowd had about one Bren gun between them—but that wasn't the Army's fault.

I am merely giving this gossip (for what it is worth) in order to show why the general public wants to see results before the Service which is undoubtedly their favourite is handed over to be used by other people. The Great British Public often have some very odd ideas and are certainly not in a position to know anything about it all—but they can make it very unpleasant for all concerned if things go wrong. That's the one right remaining to the G.B.P. in wartime.

Too Soft-hearted

To the average person, looking into the future of this war is rather like standing on the edge of a very cold bath, knowing that, sooner or later, it will be necessary to get in. It becomes more and more obvious that some tremendous efforts will have to be made and hardships undergone before we can hope to make an end of it. The Prime Minister repeatedly tells us something of the kind, but it doesn't really sink in. Unfortunately for us, we haven't had an invasion since 1066—or not one worth talking about—and we are much too easy-going and soft-hearted about the whole thing. Not about the possibility of invasion here, but about the idea of invading other people. We don't hate very easily because we've not been through the endless hell of war and invasion generation by generation.

Unfortunately, too, the crucial moments had necessarily to be passed without action—such action simply wasn't possible. Those crucial moments were such as those during the first few days of the war, when we were all on tip-toes and ready for anything; during the period of the Battle of Britain; and during the time of the massed night raids on this country. During each of those times people were hard and angry—and to invade and win we must be hard and angry, feeling neither fear nor pity. A million men must be produced with the attributes of the good Commando or Paratroop, each reckless, each angry and tired of it all, and each armed with just the right kind of weapons. A Germany weakened by more than two years of war and by the losing battle in Russia *can* be invaded and defeated by the right kind of army. No doubt the time will come, but we *must* be tough. We must be ready to die for the things that really matter.

"INDICATOR."

U.S. IN ICELAND

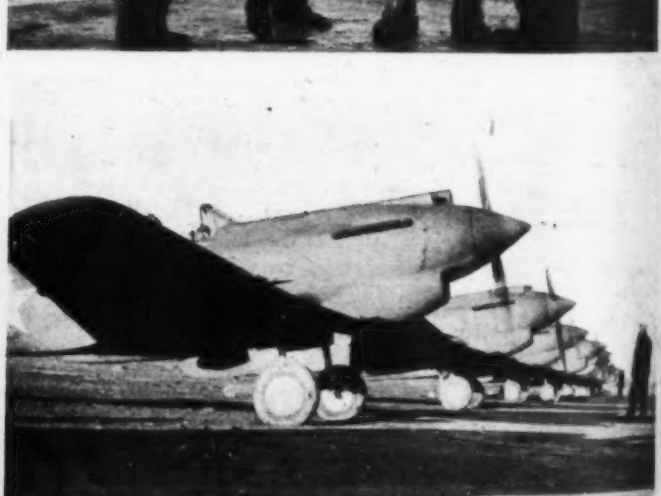
America and Britain Using the Same Airfields

ICELAND is one of the most important bases from which the Battle of the Atlantic is being fought; long and short air patrols continuously take off to watch over the shipping lanes through which our convoys pass.

Much of the country is mountainous and the few landing grounds which are available are shared by our Allies and ourselves.

These photographs were taken at an airfield from which an American Tomahawk squadron operates with a Hudson squadron of R.A.F. Coastal Command.

(Top) An R.A.F. bomb trolley passes an American Tomahawk on its way to the Hudson on the left of the photograph. (Centre) Tomahawk pilots preparing for a patrol. (Bottom left) An American pilot in the cockpit of a Tomahawk. The parachute harness is quite different from ours and the radio microphone is fitted to the throat where it picks up the sound waves direct from the vocal chords. (Bottom right) A smart line-up of Curtisses.



HERE AND THERE

Kayser Ellison Appointments

MR. ARCHIE LEIGH MORRISON, for some time London Manager of Kayser Ellison and Co., Ltd., of Sheffield, and Mr. Joseph Pashley, chief of their research department, have now been made directors of the company.

Mr. Howard Baron, A.C.A., A.C.I.S., has been appointed secretary in succession to Mr. Harry Lenton Rust.

"Miles" Men in the Forces

PHILLIPS & POWIS AIRCRAFT, LTD., are anxious to hear from former employees who left to join the Forces, so that they can add their names to their Comforts Fund list.

This fund, to which all present employees subscribe by weekly deductions from their wages, is for sending comforts to serving members of the firm and those who are prisoners of war, and they are anxious to make the list as complete as possible.

Those who are not already on the list, therefore, should send their names, with rank, number and address, to the Honorary Secretary, Phillips & Powis Comforts Fund, Reading.

Just Like Blackpool!

A BEAUFORT was approaching Brest on a job when the pilot and navigator saw a long line of riding lights stretching out into the sea for miles.

Everyone was keyed-up—the Germans might open fire at any moment. The pilot jumped when the wireless operator, a tough, stolid, Yorkshire lad, called him up on the "inter-comm."

"Yes, yes, what is it?" the pilot asked quickly—the "wireless op." must have seen a night fighter, at least, to call him at such a time.

"Have ye looked out o't window lately?" inquired the Yorkshire voice.

"Yes, yes—come on, what have you seen?" replied the pilot.

"Did ye notice all them lights—*joost like bloomin' Blackpool!*"

Invincible!

HERE is an item from the Canadian Airways, Ltd., journal, the monthly *Honker*. It reports that a Berlin military spokesman is quoted by the correspondent of the Stockholm *Tidningen* as saying:

"Complete German superiority in the East is decisively proved by the fact that the Russians are unable to prevent the Germans from retreating."

Walter Winchell, the famous American columnist, who expressed his country's neutrality at the start of the war by saying, "I'm neutral; I don't care who kills Hitler," is also credited with yet another *bon mot*.

Winchell's toast to the Japanese Navy is "Bottoms Up!"

And the same journal also quotes the film comedians, Abbott and Costello, as saying that U.S.A. has agreed to share the Pacific Ocean with the Japs on a fifty-fifty basis—the bottom half for Japan.

"The Flying Standard"

MOTORISTS will remember a Coventry-built car of this name just before the war. Now it is to be bestowed upon a fighter aircraft in recognition of the gift of £6,000 just received by the Ministry of Aircraft Production from the management, staff and employees of the Standard Motor Co.

Appropriately enough, the original "Flying Standard" was also powered by a liquid-cooled V-type engine.

Try Your Skill

THE second edition of a useful folder entitled *Aircraft Recognition Test* has just been published (price 4d.) by Rolls House Publishing Co., Ltd., for the *Air Training Corps Gazette*, in which three-view drawings of 92 British, American, German and Italian machines, by James Hay Stevens, provide good exercise in the gentle art of spotting.

All the drawings occupy one side of the sheet when it is opened out and, as they are only numbered and not placed in any particular order, the identifying of any particular one depends on recognising its outline unaided by familiarity with its position on the chart. On the other side of the sheet the drawings are indexed for quick reference.

Mr. Hamilton Kerr's Appointment

CAPTAIN H. H. BALFOUR, Under-Secretary of State for Air, has appointed Mr. Hamilton W. Kerr, M.P. for Oldham, to be his Parliamentary Private Secretary, in succession to Mr. W. W. Wakefield, who was recently appointed Director of the A.T.C.

Mr. Kerr, who is 39 years of age, worked on the *Daily Telegraph* after leaving Oxford (where he was a running blue) and became Conservative M.P. for Oldham in 1931. Two years later—at the age of 30—he was made Private Secretary to Mr. Duff Cooper and held the position for five years. In September, 1939, Mr. Kerr joined the A.A.F., and now holds the rank of Flt. Lt. His father is Mr. Henry S. Kerr, of Long Island, New York.

Officers Go Back to School

ONE of the big officers' schools of the R.A.F. has just added a "refresher" course to its activities. It is for officers up to the rank of flight lieutenant.

Although they include all branches of the R.A.F., these refresher courses are specially designed to benefit those officers of the administrative and special duties branch who did not pass through an officers' school on first appointment owing to the need to get on with the job.

Papers Into 'Planes

THIS copy of *Flight* may be made to help train air crews to fly! For when you are asked to add your newspapers to Britain's salvage store, you are adding not only to the number of our shell cases, but you are also helping to supply a vital material used in constructing a most up-to-date type of trainer aircraft for the R.A.F.

The main struts—the skeleton of this machine—are made of compressed laminated wood; and layers of newspaper are inserted to enable the wooden parts—stronger, for their weight, than steel—to be divided easily. Paper helps to give the plane greater lightness and strength.

So save up your old newspapers and journals—they are aircraft in the making, an important raw material in our struggle for air supremacy.

Safer in the Air

THERE is a young Australian wing commander in charge of a Beaufighter squadron in this country who has good reason to hold the view that he is safer in the air than on the ground.

When he was a flight lieutenant in a Spitfire squadron during the Battle of Britain, so the story goes, he was one day forced to bale out—and then the "fun" started.

He was upside down when the brollie began to open and it wrapped itself round his feet; however, he kicked it free before he ran out of altitude and landed in a potato field, somewhat winded.

But before he could get to his feet half

TOP FLOOR OFFICE: This Lockheed Lodestar, specially built and equipped for President Vargas of Brazil, has a private office for the use of His Excellency during trips between important centres of the great South American Republic. A desk, swivel chair and davenport are installed and there is also a buffet for the use of himself and his personal staff.

HERE AND THERE

a dozen determined-looking land girls came charging at him armed with pitchforks, and he had barely managed to convince them he wasn't a Hun when he found himself threatened by a Home Guard, rifle to shoulder.

Saved by a timely shout from the girls, he was put in an ambulance, which overturned on a corner, and later picked up by a fire-engine, which skidded into a ditch.

After that he decided to walk—convinced that safety was only to be found in the air these days!

R.A.F. Photo Exhibitions

ROYAL AIR FORCE exhibitions of photographs touring the principal cities and towns of the United Kingdom have just registered their one millionth visitor.

Since the first exhibition was started in London's Bond Street during the height of the Battle of Britain in 1940, six similar exhibitions have been formed. Each had about 200 of the best R.A.F. war pictures depicting all the different activities of the air war. A number of captured enemy trophies were also shown.

Altogether 54 different towns have been visited by the five units in England and Scotland, and 11 towns by a similar unit in Northern Ireland. The average attendance at each exhibition was 16,000 people.

At some of the exhibitions collections have been made for the R.A.F. Benevolent Fund, which has benefited greatly.

Canada's Output of Aircraft—

CANADA'S aircraft industry was of small dimensions at the outbreak of war, but factory floor space has been increased sevenfold and the number of workers employed from 2,300 to 32,000. Aircraft from primary trainers to big bombers are now coming off Canadian production lines at a reported rate of 2,000 a year, and operations are being constantly speeded up.

—And Aircrews, Too!

THE Royal Canadian Air Force now has a total enlisted strength at home and overseas exceeding 100,000, the Hon. C. D. Power, Air Minister, disclosed in a recent statement, which added it is fully expected that the present aim of 25 R.C.A.F. squadrons overseas will be achieved "before long."

Major Power's statement, issued a few weeks after the second anniversary of the British Commonwealth Air Training Plan, expressed confidence that the plan will soon be producing pilots, observers and wireless air gunners "far in excess of the numbers originally scheduled."

Sowing Trout by Air

THE November issue of *Indian National Airways Gazette*, which has just reached us, contains an interesting account of how the high Alpine lakes in north-western U.S.A. are restocked with young trout by the State fish and game department.

Some 10,000 of the little "fingerlings" are carried in a 40-gallon water tank in the front cockpit of a slow-flying biplane and released through a 10in. outlet from a height of 100ft. above the lake.

The Caproni-Campini jet-propelled machine at Guidonia after a successful flight from Milan. Col. Mario de Bernardi, one-time Schneider Trophy pilot, and Capt. Pedace are alongside in flying kit.

The lakes are very inaccessible, hence the use of aircraft, and it has been found that the streamlined fish straighten out, bomb fashion, to make a clean header into their new home if the pilot pulls the plug at not less than 100ft., and 99 per cent. of the fish so "delivered" are said to survive and thrive.

By this modern method the department can plant 200,000 trout in a couple of days, which is as many as the old delivery by pack horses could manage in a year.

Achtung, Typhoons!

DELIVERIES of Hawker Typhoons to R.A.F. fighter squadrons are now reported to have begun and the type may soon be in action.

Powered by the 2,400 h.p. Napier Sabre engine, the Typhoon was designed by Mr. Sydney Camm and its power-unit by Major Frank Halford—a combination of creative effort which was the subject of a special article by C. M. Poulsen in *Flight* of May 8th last year.

With a speed in excess of 400 m.p.h., the Typhoon is not likely to encounter anything faster with a swastika on its tail, while its mixed armament of machine guns and shell-firing cannon, and its protective armour, will undoubtedly be appreciated by our fighter pilots. Its range, too, is greater than that of either the Hurricane or the Spitfire.

Achtung, Jerry, here they come!

Flt. Lt. Philip Lucas, Hawker's test pilot, who was the first man to fly the Typhoon and who has nothing but enthusiasm for its performance and handling.

Bomber Command's New C.-in-C.

AIR Marshal A. T. Harris, C.B., O.B.E., A.F.C., who has been appointed C.-in-C. Bomber Command, served in the ranks of the 1st Rhodesian Regiment in the last war before joining the R.F.C. in 1915.

Awarded the A.F.C. in 1918 after service in France, he was granted a permanent commission, as squadron-leader, the following year. He subsequently served in Iraq, the Middle East and at home until, in 1937, he was promoted to air commodore and put in command of No. 4 (Bomber) Group. A year later he became A.O.C. in Palestine and Trans-Jordan, and in July, 1939, was promoted to the rank of air vice-marshal, becoming acting air marshal last June.

Air Marshal Harris, who is 50 years of age, has twice been mentioned in despatches during the present war, and was Deputy Chief of the Air Staff until May last, when he went to Washington on special duty.

Atlantic Ordeal

PROFESSOR HINTON, of the Ministry of Information, Mr. Frederick W. J. Bowley, aircraft engineer, and Mr. R. Fairey, son of the well-known aircraft manufacturer, were among a party of thirteen survivors rescued after five and a half days in an open boat in the Atlantic. Professor Hinton is now in hospital in Iceland.

Correspondence

The Editor does not hold himself responsible for the views expressed by correspondents. The names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.

RANGE AND FUEL ECONOMY

More Performance Equations

THE power factor question seems to have given rise to sufficient confusion to warrant an attempt to get to the bottom of it.

The power required for level flight is usually written

$$\text{B.H.P.} = \frac{DV}{550}$$

D being drag and V airspeed. Substitution from the ordinary formulæ gives

$$\text{B.H.P.} = \frac{C_D}{C_L^{3/2}} \cdot \frac{W^{3/2}}{550\sqrt{S\tfrac{1}{2}\rho}}$$

from which it is clear that power required varies inversely as $C_L^{3/2}/C_D$. It is easily seen that this is not the same as $L^{3/2}/D$, for the latter is

$$\frac{(C_L S\tfrac{1}{2}\rho V^2)^{3/2}}{C_D S\tfrac{1}{2}\rho V^2} = \frac{C_L^{3/2}}{C_D} \cdot V \cdot \sqrt{S\tfrac{1}{2}\rho}$$

If V were regarded as a constant, unaffected by changes of C_L, then $L^{3/2}/D$ would indeed be proportional to $C_L^{3/2}/C_D$, and its maximum would indicate the attitude requiring least power equally well. But, of course, V is a function of C_L, in level flight, and so we get

$$\frac{L^{3/2}}{D} = \frac{C_L}{C_D}\sqrt{L}$$

Putting $\sqrt{W}$ for $\sqrt{L}$, we see that $L^{3/2}/D$ is proportional to C_L/C_D, or to L/D. This simply amounts to saying that

$$L^{3/2}/D = L/D\sqrt{L} = L/D\sqrt{W}$$

which is saying the same thing in different ways.

Another approach is to manipulate the horse-power formula until it reads

$$\text{B.H.P.} = \frac{D}{L^{3/2}} \cdot \frac{W^2}{550\sqrt{SC_L\tfrac{1}{2}\rho}}$$

We might be tempted to suppose that this means that power varies inversely as $L^{3/2}/D$, but unfortunately C_L is also present, and the one is dependent on the other. The conclusion is that $C_L^{3/2}/C_D$ is the real power factor, $L^{3/2}/D$ having no particular significance in this connection.

W. E. HICK.

NO NATIONAL MONOPOLY

American Public Being Misled

YOUR Editorial in the February 5th issue of *Flight* in reply to some recent American claims for the marked superiority of their aircraft will, I feel sure, be received favourably throughout the British aircraft industry.

The particular article in the December issue of *Aviation* must have given rise to some amused astonishment over here. It is unfortunate, in my opinion, that you did not see fit to quote the passage which infers that because more Halifaxes than Fortresses have been lost, then Halifaxes must be inferior. The author attributes the discrepancy to the high-flying capabilities of the Fortress, whereas the truthful explanation is so obvious that you probably thought it unworthy of comment. However, it would have served to emphasise the species of argument on which the whole article was based. Incidentally, in all fairness, there is a misprint in the extract, "Me 109 Fs have engaged the Fortresses in combat at 40,000ft. . . ." This height should read "30,000ft.," according to the original in my possession.

The statements quoted by you, and many others which have not passed unnoticed, contrast strangely with one made by the President of the United Aircraft Corporation in a lecture to business men in Boston last October, to the effect that "Americans have an ingrained idea that everything foreign is better than the domestic." Needless to say, that he continues with the assertion that the Fortresses in the R.A.F. are the "backbone of the long-range striking force."

I am also reminded of a recent advertisement in American journals which leaves the impression that one particular type of single-seater fighter has played, and is playing, a vital part in maintaining air supremacy over this island, when, in fact, it can hardly yet have reached operational status in the R.A.F.

The American public are definitely being misled by such examples of high-pressure publicity. Surely there is one able writer in this country, well versed in matters aeronautical, who can spare the time to attempt, at least, to impress upon our cousins over the water that, although conditions prevent us from disclosing details of our latest types, the R.A.F. *does* employ *some* aircraft entirely of British design which have creditable performances and have even proved their worth in battle.

A. ANDREWS.

THE IDEAL FIGHTER

Why Twin Tail Booms?

MAY I point out to your correspondent who suggested a D-23 tandem-engine-type fighter that the extra drag of two tail booms would be abolished, and all the other advantages retained, with one exception, if a conventional aircraft using contra-props were adopted? The exception is that in this case the wheels could not be retracted into the booms; but I doubt if they could anyway, in the size of boom considered. Remember, the Fokker Company could not manage it!

I feel the artist responsible for the prone-position aircraft (appropriately on page "*g*," *Flight*, February 12th) is much nearer the mark; but why twin tails? Both the Beaufighter and the Me 210 are, I believe, single-finned; or go the whole hog and make it a tailless, as Gunter is reported to have done with the new Heinkel, and as Northrop has done in America.

SIMPLICATE.

Vulnerability

UPON reading "2/Lt. R.A.'s" remarks on the "Ideal Fighter" in your issue for February 12th, it seemed to me that his criticism is a little one-sided. He stresses the magnitude of the complication of the airscrew gear through which the tail stresses must be carried, and the controls pass. But I think this is not as great as he makes out.

In his version of the ideal fighter there is still vulnerability, from tail attack, to the rear engine, which he points out as a fault in central airscrews, and "buried" engines. He has not, as he admits, solved the problem of baling out, as there is still a rear airscrew. As for the pilot being exposed, does it matter much to the pilot whether he is trapped between the rear engine and some hard obstacle, or the rear engine and the front one, in the event of a rough forced landing? As for flying on one engine, or fighting, the former may be possible if the rear engine failed, but if the forward one failed the balance would be so much upset as to make flying, let alone fighting, very difficult.

There are several other disadvantages:—

(1) Great increase of weight, which would offset any advantage in speed, since the fuel and the extra engine would mean such an increase the wings would have to be built larger to keep the loading anything like reasonable, consequently causing a lengthening of the tail booms and loss of speed.

(2) Phenomenally small undercarriage units would be needed for stowage in the booms, since the main armament, and the tail unit controls, would have to pass there, causing much complication. The fuel, armament and undercarriage are all outboard, which would lessen manœuvrability.

The pilot's morale has not been increased by adopting his design rather than the "central airscrew" system.

I do not think there are grounds for saying that the nose would cave in; if the nose of a machine can be built to hold a heavy engine in place for a crash landing, surely it could resist the same forces without the engine? A single sheet of armour plating is the best method of protecting the pilot, rather than introducing another engine to do so.

The only advantage would seem to be that the radiators are, in his version, in the slip-stream, which suggests he has made the hand fit the glove rather than vice versa.

He omits the disadvantage of a central airscrew—that the blades would be very difficult to feather.

It seems to me that the disadvantages of the tandem layout offset any advantages gained.

JUSTIN GRFALY.

FEATURES OF LUBRICATION

The Structural Changes in Bearing Faces During Operation and How Lubrication Affects Them

IT has been revealed in research work during the past few years that there is more in lubrication than hitherto was supposed. Thus one has been apt to think of lubrication as being a film of oil between two rubbing faces, but it is now clear that conditions are more complex than this.

The new views on the subject have been promoted largely by the development of optical instruments such as the electron diffraction camera and delicate measuring devices in which the physicist has joined efforts with the chemist, the metallurgist and the engineer. The results of this team work have proved the value of co-ordinated research work and we are now in a much better position to understand why certain bearings give better results than others, why lubricating oils behave so differently, and last, but not least, the facts uncovered have provided a signpost to the future progress in the design of mechanical equipment.

To understand lubrication it is imperative to know what happens to a bearing face during its initial life. Briefly, there are two states in which bearing metal can exist, the crystalline and amorphous. It is largely the inability to realise that the latter state plays an important part in the life of a lubricated metallic face that may have impeded progress in our knowledge about lubrication. The crystalline condition of any substance is characterised by an internal symmetrical atomic arrangement. For the most part, metals can be classed crystallographically as cubic or hexagonal. Many of the well-known metals, such as copper, nickel, iron and chromium, crystallise either as body-centred cubes, face-centred cubes or close-packed hexagonal forms. Metallography has carefully sorted out and listed the characteristics of crystalline metals. To acquire a knowledge about the amorphous condition, however, it has been necessary to employ equipment, as for instance the electron diffraction camera, which goes beyond the range of optical resolution in the microscope used by the metallurgist.

When a beam of electrons is projected on to a crystalline surface the former is diffracted, and when caught on a photographic plate gives rise to a characteristic pattern. A typical electron diffraction pattern, due to Finch, for a crystalline metal, in this case nickel, is shown in Fig. 1. The concentric circles reveal the positions of the atom layers. If now a metallic face which is amorphous, that is to say in which the atoms are ranged at random, is examined with an electric beam, a halo pattern characteristic of the Beilby layer is revealed as in Fig. 2.

How Bearing Structures Affect Lubrication

At first sight it might not seem that the arrangement of the atoms in a bearing face will play a part in lubrication or metallic wear, but the contrary is true and an amorphous layer of metal formed on a bearing face during its initial life may offer greater resistance to wear, while it tends to be smoother in outline and may sometimes be extremely hard. It should be explained that when a new bearing is put into operation the immediate surface tends to flow in a viscous fashion, which is accompanied by a change in the flowed metal from the normal crystalline condition to the amorphous state. Thus high spots which are left on the bearing after the machining operations are melted by high localised temperature, a phenomenon examined by Bowden, and tend to be modelled down plastically. It should be clearly understood, however, that such a change can only occur when direct abrasion is absent; that is to say, opposite rubbing faces must be protected from metal-to-metal contact as much as possible. Abrasion means that crystals of metal in one face are torn out by projections on the opposite face and one gets the condition known as abrasive wear.

The necessity for protective lubrication is clearly seen, and that is why running-in is accorded the care it is by engine manufacturers. During those early hours of running, bearing surfaces are "conditioned," to use a coined expression. Such "conditioning" implies a change from the crystalline to the amorphous state accompanied by a smoothing out of high spots plastically instead or by pure abrasion. In effect one can ensure running-in with the minimum wear while at the same time the requisite degree of smoothness of a bearing face is obtained. Certain other changes appear to take place during the process of "conditioning" which enable the bearing face to yield a higher life and better performance.

Fig. 1.—Electron diffraction pattern of nickel. The concentric rings indicate the spacing of the atoms in nickel. The central bright spot is due to the undeflected electron beam striking the photographic plate.

The Behaviour of Lubricants

In a paper to the Royal Aeronautical Society a few years ago, Pye drew an apt analogy between the molecules of an oil on a bearing face and a field of corn. The stalks of corn would be rooted in the earth and if pressed would lean over, maintaining a roughly parallel position to each other. This is what happens when the film of oil on a metallic face is subjected to pressure. Paraffin molecules in an oil do not tend to anchor themselves to a metal face, and it is for that reason that certain active molecules are sometimes added to a straight mineral oil. Nevertheless, during running-in, main problems, as indicated by Blok, an eminent authority on lubrication, are high localised temperature, sometimes accompanied by high localised pressure, both of which give rise to boundary conditions of lubrication.

Owing to the difficulties experienced during the running-in of various types of harder bearings, the possibilities of pre-treatment have been investigated. Thus it is argued if a face can be given good bearing and anti-friction qualities beforehand, running-in will be assisted materially. Experiments by Finch and

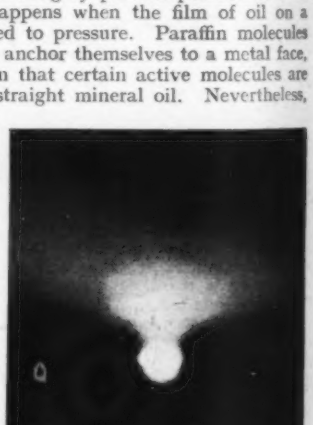


Fig. 2.—When an electron beam is directed on to a surface in which the atoms have no symmetrical order the beam gives rise to a halo pattern on the photographic plate. This is an important test to determine the state of a bearing face, that shown being amorphous, or non-crystalline.

Whitmore have thrown light on this subject, experiments in which they run-in mild-steel faces with oil containing "dag" colloidal graphite, then continue the lubrication with plain oil. On examining the face by electron diffraction it was observed that the surface metal was amorphous. Fig. 2 is the pattern they obtained, the halo pattern being characteristic of the known random arrangement of the atoms in the surface. Friction measurements showed, however, that the face resisted seizure to a greater extent than one which had been run-in on plain oil, while it also gave a lower friction value. The reason for this was not clear until the surface was etched off. Particles of graphite were revealed below the surface layers of metal, as shown in Fig. 3.

Fig. 3.—The thin amorphous layer of metal in Fig. 2 has been etched off to reveal the diffraction spots due to very fine particles of colloidal graphite, which form an anti-seizing sub-layer below the metal. This is distinct from the graphoid surface which lies on top of a metal face.

There is only one likely explanation for this curious behaviour. During the plastic flow of the surface metal in the face of mild steel the sub-microscopic particles of graphite must have been rolled in and eventually covered over by amorphous metal when the plain oil lubrication was continued. Particles of colloidal graphite can be rolled in by this method to most metals, both ferrous and non-ferrous, so that the latter acquire the low friction qualities of cast iron and also retain their own tensile properties. It should be remembered that this phenomenon of surface flow occurs only in the immediate surface of a bearing face and may be less than 1/10,000in. in depth.

Characteristics of Colloidal Graphite

A great deal of research work has been carried out on this interesting lubricant, which is now used in oil and other carriers for engines and mechanical equipment of many kinds. Tests carried out at the National Physical Laboratory some years ago show that it tends to increase the load-carrying capacity of an oil used in a journal bearing. Tests by Shaw have subsequently confirmed the earlier observations and he has illustrated graphically how colloidal graphite of the right technical quality can protect a bearing face from seizure for many hours after the supply of oil has broken down. A typical result is shown in Fig. 4. Hardened-steel shafts were run in lead bronze bearings, at 445ft. per minute and 1,038ft. per minute in two separate tests. The load was varied from 200 lb./sq. in. to 1,300 lb./sq. in. The bearings had previously been run-in for 10 hours before tests were carried out, the shafts being fine ground. It will be seen that the graphited oil enabled loading to be extended up to 1,300 lb./sq. in. without seizure, while the plain oil seized at 600 lb./sq. in.

Fig. 5 shows the structure of a metallic face which has been treated with "dag" colloidal graphite. The diffraction spots reveal that the minute flat lubricating particles of graphite are lying like tiles on the substrate in such a position that not only do they offer the maximum lubrication, but protect the underlying metal from abrasion and from corrosion. The graphite particles are adsorbed to the metal and consequently cannot be removed, so that they provide a sure line of protection against seizure.

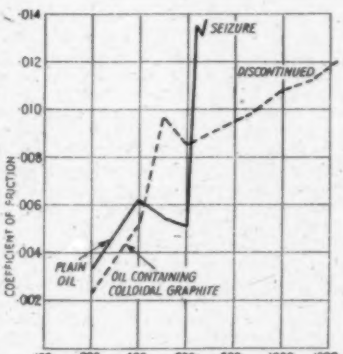


Fig. 4.

The Practical Problem in the Aeronautical Field

It is clear that with the necessity for maximum performance from aircraft engines lubrication assumes first-class importance. It might be said that such problems as do occur are usually to be found during the production of equipment in so far as the engine or auxiliary, once it has been run-in, is free from trouble. The employment of lead bronze and cadmium nickel bearings have given rise to their own peculiar problems, particularly during running-in. Then, again, the widespread adoption of aluminium pistons, frequently anodised, has called for the utmost vigilance from the research and production engineer. Valves, again, like the topmost parts of the cylinder of an engine, have to be lubricated under high temperature conditions. In this connection the value of colloidal graphite for high-temperature work has been clearly shown, and it is now specified by manufacturers of high-temperature equipment where oils and greases could not be used.

Fig. 5.—An excellent example of electron diffraction is offered by this pattern of a slippery graphoid surface formed on a bearing metal with colloidal graphite. The graphite has a sheet-like atomic structure and when the colloidal particles lie flat on a metallic face they present a surface to the electron beam in which the atoms are in parallel layers. Consequently the reinforcement of the beam from successive layers gives rise to the diffraction spots shown.

For some years engine manufacturers have adopted the practice of painting on, and in some cases rubbing on, dispersions of colloidal graphite in oil, or in other suitable carriers. Subsequent rubbing produces a slippery graphoid surface as indicated by the diffraction pattern of Fig. 5. An alternative method is to paint on a preparation made up of "Aquadag" colloidal graphite in water, gelatine and potassium dichromate as suggested by Stuart. Such a preparation produces a coating which can be hardened by exposure to light or by baking. The coating is not only hard and durable, but enables difficult bearing materials to be run-in satisfactorily.

In conclusion a reference should be made to the practice now becoming widespread of using colloidal graphite in volatile carriers, such as carbon tetrachloride, white spirit and acetone. When brushed on to metallic and non-metallic faces they form quickly and conveniently dry graphite coatings which are lubricant and protective. It will be seen from the above notes that there is a tendency for emphasis to be laid on what might be termed pre-lubrication of metallic faces in engines and other equipment.

This also applies to many mechanical parts in aircraft engineering, particularly where very low clearances are necessary between working faces or where protection against seizure or undue wear must be guarded against at all costs. The structural changes in metal during running-in which have been referred to above point a moral: it is the necessity for seeing in lubrication more than a mere oil film and to consider the bearing face as tied up very closely with the mechanism of lubrication.

WORLD PRESS SUMMARY

RÉSUMÉ OF TECHNICAL ARTICLES DEALING WITH AIRCRAFT AND ASSOCIATED SUBJECTS

For the summaries and translations from aircraft and technical journals of the world, we are indebted to the Directorate of Scientific Research and Technical Development, Ministry of Aircraft Production.

Multi-bladed Airscrews

THE experiments were carried out in the 2 m. wind tunnel on model propeller having 0.94 m diameter, and covered assemblies of 2, 3, 4, 5 and 6 blades of identical design. Thrust, torque and efficiency were determined over a range of blade settings and V/nD values for each assembly, and the results are recorded in a series of tables and curves.

Of special interest is the very large range of V/nD covered, amounting to 9.4, 7.4, 3.7, 3.7, 3.7 for the 2, 3, 4, 5 and 6 blade assemblies respectively. For most of the tests the airscrew r.p.m. varied only slightly (700-900 r.p.m.), and as a consequence the Reynolds number of the 0.7R section increased from about 1×10^5 to 3×10^5 over the experimental range.

The following are some of the principal conclusions:

1. With the screws turning at a fixed point (V = 0) the thrust coefficient remains practically constant over the range of blade setting angles $\beta = 30°$ to $50°$. The thrust coefficient increases almost linearly with β over the range $\beta = 0$ to $20°$.

2. Under the same conditions (V = 0) the torque coefficient increases continually with β.

3. The V/nD value corresponding to zero thrust or torque are functions of β only and independent of the number of blades.

4. The envelope of the various efficiency peaks is practically horizontal over the range V/nD = 1 to 2, and falls off relatively slowly for larger values of V/nD. In case of the 2-bladed airscrew, an efficiency of 59 per cent. obtained at V/nD = 4.5 ($\beta = 72°$).

5. The maximum efficiency diminishes slowly with increasing number of blades (82 per cent. 2 blades to 78 per cent. 6 blades).

6. Maximum possible efficiency occurs at $\beta \sim 40°$ and V/nD = 1.5, irrespective of number of blades.

7. At maximum possible efficiency, increasing the blade number n from 2 to 6, increases the thrust and torque coefficients by multiples of 2.5 and 2.7 respectively.

8. It is suggested that 4-bladed propellers are likely to prove of benefit for high-speed and high-power operation at high altitudes.

Experiments with a Family of Multi-bladed Airscrews.—(A. Eula, *Atti di Guidonia.*) (Italy.)

Aircraft Performance

A METHOD is presented for rapidly determining the effect of small modifications in the various parameters influencing performance. The only requirements for use of this method are performance values for some basic condition and the corresponding aircraft polar curve. No recourse is necessary to analytical methods of performance calculation, but only the fundamental concepts of power available and power required.

The resulting expressions lead to some interesting corrolaries dealing with critical values of the parameters.

Thus, the lift coefficient on the aircraft polar diagram corresponding to minimum power required satisfies the simple relation

$$\frac{d C_D}{d C_L} = \frac{3}{2} \frac{C_D}{C_L}$$

At optimum wing loading we have

$$\frac{d C_D}{d C_L} = \frac{C_{Dw}}{C_L}$$

when C_{Dw} = drag coefficient of wing alone.

(This means that the slope of the aircraft polar is equal to L/D of the wing.) Finally at the altitude for minimum drag,

$$\frac{d C_D}{d C_L} = C_L/C_D$$

This corresponds to the best L/D point on the polar curve and, therefore, to minimum drag for a given weight. Below the lift coefficient corresponding to this point, an increase in altitude at constant power available results in an increase in level flight speed or rate of climb, while above it, the reverse takes place. This critical point thus determines the intersection of power required curves for adjacent altitudes. It also locates the altitude beyond which supercharging is ineffective. Beyond this there is no increase in speed at constant power.

A Simplified Method for Predicting the Change in Aeroplane Performance Due to a Change in Parameter.—(E. C. Posner, *J. of Aer. Sci.*, Vol. 8, No. 11, Sept., 1941, pp. 419/25. (U.S.A.))

Elliptic Wings

THE correction commonly applied is that introduced by Prandtl and known as the lifting-line theory. The downflow induced by the wake is considered, in this theory, to reduce the relative normal velocity and hence the edge velocity of the wing. It is assumed, however, that once the true angle of attack is determined for any section of the wing its effect in producing circulation and lift is the same as in two-dimensional flow. This assumption is expressed by the equation

$$C_L = 2\pi (\alpha - \alpha_1) \quad \ldots \quad (1)$$

where 2π is the slope of the lift curve for the thin wing of infinite aspect ratio, α is the angle of attack of downflow.

Eq. (1) takes into account the effect of the wake in diminishing the relative normal velocity of the wing. A further correction is indicated by the fact, established in hydrodynamic theory, that the surface velocities induced by a given relative motion of a body in three-dimensional flow are generally smaller than those in two.

In the case of an elliptic disc the velocity at every point is reduced by the factor 1/E, where E is the ratio of the semi-perimeter of the ellipse to the span.

The corrected formula for the lift is then

$$C_L = (2\pi/E) (\alpha - \alpha_1) \quad \ldots \quad (2)$$

Since the velocity of the non-lifting potential flow is constant all around the edge of the elliptic plate, the circulation required will be proportional to the chord at each section. The circulation is thus elliptically distributed spanwise. Such a distribution, with the chord-wise distribution assumed earlier, leads, as in the lifting-line theory, to the relation

$$\alpha_1 = C_L/\pi A \quad \ldots \quad (3)$$

where A is the aspect ratio.

Substitution of this value into Eq. (2) gives

$$C_L = 2\pi\alpha A/(EA+2) \quad \ldots \quad (4)$$

Since the chordwise distribution of the circulation in three-dimensional flow is assumed similar to that in two, and since the similarity is only proved for the non-circulatory flow, Eq. (4) must be considered a correction of the wing-section theory rather than a solution of the three-dimensional problem. The assumption of similarity, although its validity is subject to somewhat the same limitations in general, appears to be a more justifiable one than the assumption of equality made in the lifting-line theory.

It is found that the additional correction to the wing-section theory accounts for an appreciable fraction of the loss in lift that is usually attributed to viscosity. It has been difficult to reconcile the magnitude of the inefficiency with the observed dimensions of the wake, which, in the case of smooth wings, is extremely narrow at the trailing edge. The foregoing correction accounts for as much as half of this discrepancy in cases of wings with sharp trailing edges.

Theoretical Correction for the Lift of Elliptic Wings. (R. T. Jones, *J. Aeron. Sci.* (U.S.A.))

SERVICE AVIATION

ALARM—AMERICAN VERSION : Fighter pilots of the U.S. Army Air Corps running to their Airacobras.

Royal Air Force and Fleet Air Arm News and Announcements

Awards

THE KING has been graciously pleased to approve the following awards in recognition of gallantry displayed in flying operations against the enemy :—

DISTINGUISHED SERVICE ORDER.

Act. Grp. Capt. K. B. B. CROSS, D.F.C.—Since the commencement of operations in the Libyan campaign, this officer has displayed inspiring leadership. In spite of his ground control duties, Grp. Capt. Cross has consistently participated in the air operations and his indomitable courage and skill have contributed materially to the fighting efficiency of the force he commands.

Act. Wing Cdr. F. E. ROSIER.—This officer has commanded a fighter wing since the commencement of the operations in Libya, both in the air and on the ground. His courage and efficiency have been inspiring throughout. On one occasion, when one of our fighter wings was being attacked by a large number of enemy aircraft, Wing Cdr. Rosier joined in the engagement. When breaking clear he observed one of our pilots who had been forced to land in enemy territory and, in an attempt to rescue him, Wing Cdr. Rosier landed his aircraft.

He was unable to take off again owing to the close proximity of enemy forces. Nevertheless, both pilots eventually got away and, after many narrow escapes, succeeded in regaining base after a period of three days. Wing Cdr. Rosier is an outstanding fighter pilot and leader.

Flt. Lt. P. R. BURTON-GYLES, D.F.C. No. 44 (Rhodesia) Squadron.—This officer has completed many sorties, including several attacks on the enemy warships at Brest and on important industrial targets in Germany. On one occasion in October, 1941, after successfully bombing Cologne, Flt. Lt. Burton-Gyles descended to almost ground level and attacked gun posts, which were partly silenced.

In December, 1941, Flt. Lt. Burton-Gyles carried out a difficult mine-laying mission. Despite anti-aircraft fire and interference from an enemy fighter, whose pilot attacked a few seconds before Flt. Lt. Burton-Gyles had placed his mine, the task was successfully accomplished. Although his aircraft was seriously damaged (the starboard aileron and the starboard rudder control were shot away), Flt. Lt. Burton-Gyles, by superb airmanship, succeeded in flying back to this country, where he made a safe landing. This officer has consistently displayed outstanding qualities of leadership, and has set a splendid example to all.

BAR TO THE DISTINGUISHED FLYING CROSS.

Act. Wing Cdr. H. C. MAYERS, D.F.C., R.A.F.V.R., No. 94 Squadron.—This officer has led his wing on a large number of sorties during the Libyan campaign. His mastery of tactics and skilful planning of operations have contributed largely to the many successes obtained.

One day in December, 1941, during a machine gun attack against an enemy column, Wing Cdr. Mayers observed a member of his formation shot down by anti-aircraft fire. When the attack was concluded, he skilfully landed near the crashed aircraft and, although enemy vehicles were approaching, coolly waited for his comrade to reach him. Putting him in the seat, Wing Cdr. Mayers clambered in on top of him and took off as the enemy neared the aircraft. He finally flew safely to base. This officer has always shown great courage and leadership. He has destroyed at least 11 enemy aircraft.

Act. Sqn. Ldr. A. C. P. CLAYTON, D.F.C. No. 408 (R.C.A.F.) Squadron.—This officer has carried out a number of further sorties since being awarded the D.F.C. On all occasions he has shown great determination and leadership, and he has contributed largely to the successes obtained. In September, 1941, Sqn. Ldr. Clayton led a sub-formation on daylight raids on targets in Northern France. One raid on Lille was particularly successful, and reflected much credit on the skill and leadership of this officer. Throughout, he has set a fine example.

Act. Sqn. Ldr. J. R. RAINFORD, D.F.C. No. 83 Squadron.—Since being awarded the D.F.C., this officer has completed a number of sorties, including attacks on Kiel, Berlin, Frankfurt, and other targets in Germany. In November, 1941, he made a successful attack on an enemy convoy. One night

Prince Bernhardt and Sir Sholto Douglas at the recent presentation of colours to the Belgian Fighter Squadron.

SERVICE AVIATION

in December, 1941, Sqn. Ldr. Rainford bombed Aachen and then machine-gunned two railway trains from a height of only 50 feet. Shortly afterwards he successfully accomplished a mine-laying mission.

In addition to his splendid work in the air, Sqn. Ldr. Rainford has evinced the greatest interest in the administration and general welfare of his flight. His encouragement and training of crews under his command has proved a source of inspiration.

DISTINGUISHED FLYING CROSS.

Sqn. Ldr. V. B. CORBETT, R.C.A.F., No. 402 Squadron.—This officer has led his squadron on numerous bomber escorts over enemy occupied territory in France. Throughout he has displayed great skill and leadership which have undoubtedly played a large part in the splendid protection afforded to the bomber formations.

During these operations, Sqn. Ldr. Corbett has destroyed at least one enemy aircraft and damaged several others. He has also participated in numerous low flying attacks on enemy territory, during which his tactical ability and fine fighting spirit have proved an inspiration. This officer, who fought in the Battle of Britain, has always displayed the greatest keenness.

Act. Sqn. Ldr. E. W. MURRAY, No. 11 Squadron.—This officer has participated in many sorties, most of which have been carried out during recent operations in Libya. He has at all times shown great skill and resource. In December, 1941, during an attack on enemy concentrations in the Mekili area, Sqn. Ldr. Murray's aircraft received a direct hit from a small shell which cut the aileron controls and bent the throttle controls. In spite of this, Sqn. Ldr. Murray maintained formation and, on return to base, landed his aircraft without causing it further damage. He has set an excellent example.

Act. Flt. Lt. C. C. CALDER, R.A.F.V.R., No. 76 Squadron.—This officer has shown the greatest keenness and determination to inflict the maximum damage on the enemy. In December, 1941, he was detailed to lead a formation of Halifax aircraft in a daylight attack on the *Scharnhorst* and *Gneisenau* at Brest.

On arriving at the head of the runway, the aircraft brake-pressure failed. Flt. Lt. Calder immediately got his aircraft clear of the runway, and so quickly obtained the stand-by aircraft and took off that he was able to lead the formation to the rendezvous according to schedule. His leadership contributed much to the success achieved. Flt. Lt. Calder has participated in attacks on Mannheim, Emden, Cherbourg, Berlin and Hamburg.

Act. Flt. Lt. D. F. BENBOW, No. 37 Squadron.—This officer, who has commenced a second tour of operational flying as captain of aircraft, has made raids on Germany and occupied territory, Cyrenaica, Greece and the Dodecanese. He has on several occasions experienced serious difficulties. In the course of one operation, his starboard engine caught fire when returning from Gazala, and on another occasion his aircraft was seriously damaged by enemy fire over Benghazi, but by an admirable display of coolness and skill Flt. Lt. Benbow was able to surmount these dangerous situations. Throughout, this officer has shown great enthusiasm and devotion to duty.

DISTINGUISHED FLYING MEDAL.

Sgt. R. J. WHITTLE, R.A.A.F., No. 250 Squadron.—This airman has proved himself to be a courageous and skilful fighter pilot. In one engagement when his formation was fighting against a superior number of enemy aircraft Sgt. Whittle destroyed two, probably destroyed another, and damaged a further two of the enemy's aircraft.

His determination is such that, on one occasion after being shot down, he walked 30 miles during the night rejoining his squadron for duty the next day. During an engagement two days later, Sgt. Whittle was wounded in the foot and arm and his aircraft was badly damaged, but he flew back to base where he made a successful forced landing. Within two days, Sgt. Whittle resumed operational flying. He has destroyed at least seven enemy aircraft.

Sgt. M. G. TURNER, R.N.Z.A.F., No. 103 Squadron.—As a navigator, this airman has taken part in attacks on Germany which have included Cologne, Hamburg, Bremen, Emden, Essen and Berlin. Sgt. Turner has proved himself to be a first-class navigator and throughout his fine record of achievement he has displayed courage and coolness of a high order. His cheerful confidence and fine spirit have set a magnificent example to the squadron.

Sgt. E. W. WISEMAN, R.A.F.V.R., No. 150 Squadron.—This airman has taken part as a front gunner or first wireless operator in attacks against many enemy targets, including Berlin and the naval base at Kiel. Sgt. Wiseman's courage, ability and consistent keenness in his work have largely contributed to the successful operations carried out. He has set an excellent example, and his ability as front gunner has instilled great confidence in crews with whom he has flown.

Sgt. A. C. SPENCER, No. 101 Squadron.—One night in January 1942, this airman was the navigator-bomb aimer of an aircraft which successfully attacked Hamburg. Bombs were released over the target but the aircraft was hit by enemy fire, and Sgt. Spencer received a wound in the left thigh. Although in great pain, he continued his navigational duties; he also set down courses for use in case he collapsed.

When it was found that all the bombs had not been released, he dragged himself to the bomb aimer's position and jettisoned the remaining bombs. Showing great fortitude, Sgt. Spencer then navigated the aircraft safely back to this country.

Air Sgt. P. H. KLEYN, S.A.A.F., No. 12 Squadron.—This airman was first employed as an air gunner and afterwards as observer, acting as such without previous training or attending a recognised observer's course. Nevertheless, his navigation has been good and his bomb aiming beyond reproach. Air Sgt. Kleyn has been on active service since May, 1940, and throughout he has set a worthy example.

Sgt. L. H. MELLOR, R.A.A.F., No. 37 Squadron.—This airman has participated in attacks on targets in France, Cyrenaica, Syria, Dodecanese, Greece and Tripolitania. Recently Sgt. Mellor carried out four raids on Tripoli Harbour from an exceedingly low altitude, pressing home his attacks with great determination. This airman has invariably displayed a high standard of courage and skill as captain of aircraft.

Flt. Sgt. D. FOSTER, No. 408 (R.C.A.F.) Squadron.—This airman has participated in a large number of sorties as wireless operator-air gunner. He has taken part in raids which have included Lille, Hamburg, Mannheim and Dusseldorf. His wireless duties have invariably been carried out with skill and judgment. During daylight raids on Lille in September, Flt. Sgt. Foster used his guns with good effect and assisted materially in repelling enemy fighters who attempted to attack the formation. He has always shown courage and devotion to duty.

Flt. Sgt. A. STEPHENSON, R.A.F.V.R., No. 82 Squadron.—This airman has completed many sorties, most of which have been by day. Throughout these sorties, including attacks on the enemy's shipping, airdromes, dock installations and factories, Flt. Sgt. Stephenson has shown a high standard of navigational efficiency and determination. As an air observer to the squadron commander, this airman has contributed materially to the successes achieved. He has displayed great devotion to duty and set an excellent example.

Flt. Sgt. R. W. TAYLOR, R.A.A.F., No. 7 Squadron (since deceased).—In December, 1941, this airman was the captain of an aircraft which participated in a daylight attack on the battle cruisers in Brest harbour. Despite intense anti-aircraft fire and fighter opposition, Flt. Sgt. Taylor displayed the highest standard of flying skill and air tactics and never lost formation throughout the attack.

In November, 1941, he was captain of a Stirling aircraft which participated in a daylight attack on shipping off Borkum. During the operation the aircraft were intercepted by eight Messerschmitt 109's, of which two were shot down and one was engaged. Flt. Sgt. Taylor has taken part in many major attacks against important targets in enemy country. Throughout he has shown the greatest courage and determination.

Sgt. R. J. COOK, R.A.F.V.R., No. 15 Squadron.—This airman has participated in sorties against enemy targets, including dockyards, railways, oil refineries, airdromes and other targets in enemy country. He has participated in attacks on Berlin on four occasions.

In December, 1941, Sgt. Cook was the observer of the leading aircraft of a formation of Stirlings which took part in a daylight raid on the enemy warships at Brest. His precise navigation enabled the formation to bomb their objective at exactly the stipulated time, in spite of fierce opposition. Sgt. Cook is a most efficient navigator-bomb aimer who has consistently displayed courage and perseverance.

Sgt. D. L. DANIEL, No. 106 Squadron.—After successful flights as a navigator, Sgt. Daniel qualified as a first pilot, and, as such, he has carried out further sorties with good results. He has made raids on many of the most important targets, including an attack on Berlin, when he scored hits on the main objective. Undeterred by the strongest opposition, Sgt. Daniel has frequently flown his aircraft over the target at a low altitude. He has carried out his tasks with skill, courage and enthusiasm.

Their Majesties the King and Queen talking to Miss Pauline Gower, M.B.E., during a visit to one of the Auxiliary Air Transport stations.

Roll of Honour

Casualty Communique No. 110.

THE Air Ministry regret to announce the following casualties on various dates. The next-of-kin have been informed. Casualties reported "in action" are due to flying operations against the enemy; "on active service" includes ground casualties due to enemy action, non-operational flying casualties, fatal accidents and natural deaths.

Royal Air Force

KILLED IN ACTION.—Sgt. E. Ewings; P/O. J. D. Gilliland; Sgt. V. H. Mountstephens; Sgt. R. McK. Rhodes; Act. Flt. Lt. R. J. Roach; Sgt. L. J. Roe; Sgt. R. L. N. Simmons.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. W. F. Alexander; Sgt. J. J. Berry; Flt. Lt. G. H. Bowes; Sgt. N. F. Brotherton; Sgt. W. M. Caine; Wing Cdr. W. E. Coope; Sgt. A. Critchlow; P/O. V. D. Durham; Sgt. C. P. Edwards; Act. Flt. Lt. G. M. Fairbairn; Flt. Sgt. C. E. Fowler; P/O. P. J. Higgins; Sgt. S. W. Kemp; Sgt. P. G. Marsh; Sgt. H. R. Mason; Sgt. H. J. Mew; Flt. Sgt. D. F. Meyrick; Sgt. J. Rowe; Flt. Sgt. A. H. S. Waller; Sgt. C. E. Whitfield.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—P/O. G. R. N. Adams; Sgt. T. R. Alston; F/O. J. Beveridge; Sgt. W. K. Blackford; Sgt. S. B. Bransby; P/O. V. K. Brown; Flt. Sgt. W. McL. Crichton; Sgt. F. A. Culham; Cpl. W. C. Davis; Sgt. F. G. C. Downes; Sgt. R. W. Dunkley; Sgt. L. S. Dyer; Sgt. R. Fawcett; Sgt. G. I. Gane; Sgt. S. N. S. Goodlet; Sgt. A. Gosden; Sgt. G. E. Green; Sgt. V. J. Griffiths; F/O. J. L. Halstead; Flt. Sgt. T. E. Hampson; P/O. G. V. Heslop; Sgt. L. Hird; Flt. Sgt. R. G. Jones; Sgt. J. G. Keymer; Sgt. D. K. McFarland; Sgt. R. R. Mann; F/O. E. S. Marrs, D.F.C.; Sgt. T. N. Menage; Sgt. P. A. O. W. Mitchell; Sgt. J. Money; Sgt. F. C. Ockenden; Sgt. D. Onions; Sgt. J. A. A. Parker; Sgt. S. Parr; Sgt. A. H. K. Pedley; Sgt. D. H. J. Pingel; Sgt. T. C. Pugh; Sgt. A. G. Rickcord; P/O. G. E. J. Rushbrooke; P/O. E. G. Smith; Sgt. L. G. Sutherland; Flt. Sgt. J. R. Taylor; Sgt. C. S. Thomson; Sgt. W. G. Thorneycroft; Flt. Sgt. A. J. Waring.

WOUNDED OR INJURED IN ACTION.—Sgt. D. S. Bright; Sgt. F. H. Cochrane; Sgt. W. E. Copp;

SERVICE

Sgt. J. L. Coulthard; Act. Sqn. Ldr. E. B. Mortimer-Rose, D.F.C.

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—Sgt. R. W. Forman; P/O. J. G. Hentherington; Sgt. R. H. J. Winter.

MISSING.—Flt. Sgt. R. Atkin; F/O. J. H. Baker; Sgt. J. Bayliss; Sgt. J. L. Bell; P/O. A. E. J. Bourner; Sgt. J. Burns; Sgt. P. A. Craig; Sqn. Ldr. C. F. Darbishire; Sgt. E. S. Fender; Sgt. C. T. Fletcher; Sgt. M. C. Fletcher; Sgt. L. A. Fox; Flt. Sgt. F. F. Garrity, D.F.M.; Sgt. A. S. Greaves; Sgt. H. Hamer; Flt. Lt. M. T. Harries; P/O. H. D. C. Henderson; Sgt. S. C. Herbert; Sgt. D. A. Hince; Flt. Sgt. J. Hood; P/O. D. Jacobs; Sgt. R. J. Ledlie; F/O. N. K. Lee; Sgt. M. H. McDonald; Sgt. L. J. Macey; P/O. J. M. Marchington; P/O. M. Murphy; Sgt. K. Naylor; P/O. K. P. S. O'Donnell; Sgt. J. A. Redfearn; Sgt. R. E. J. Reeves; Sgt. J. V. Rowe; Sgt. R. Rust; Flt. Lt. E. W. Seymour-Hosley; Sgt. W. L. Taylerson; Sgt. E. B. Thomas; Sgt. T. H. Trinder; Sgt. J. C. B. Webster; Sgt. J. E. Wilcock; Sgt. G. Wiscombe.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—Flt. Lt. W. S. Rea, D.F.C.; Flt. Lt. R. J. Vaughan, D.F.C.

KILLED ON ACTIVE SERVICE.—L.A/C. F. G. Barber; Sgt. D. J. Bartell; Sgt. D. Clark; Cpl. R. S. Cohen; Cpl. R. H. Dear; L.A/C. D. P. Dick-Cleland; Sgt. A. J. Gearing; Sgt. W. Jowett; L.A/C. G. J. King; L.A/C. J. C. Lambert; Sgt. S. Lee; Sgt. R. W. Magson; Sgt. R. M. Masson; Flt. Sgt. H. Mennie; L.A/C. J. D. Nevitt; Sgt. J. E. Orton; Sgt. W. G. Pengelley; P/O. A. N. Prior; F/O. J. W. Rae; Act. Sgt. H. R. S. Treacy; Sgt. D. E. Tuson; Act. F/O. G. G. Waddington; Sgt. J. W. Watson; A/C.2 P. Woodward.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. J. Charlesworth; A/C.1 S. G. Gurney.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—A/C.2 C. E. Butler; W/O. A. Bruines; Sgt. J. Christie; A/C.2 F. W. Redgate; A/C.1 H. Richardson; L.A/C. C. A. Ripley; A/C.1 A. J. Rouse; A/C.1 W. Scrugham; A/C.1 S. Seddon; A/C.1 J. Segar; L.A/C. G. I. Simpson; L.A/C. D. A. Smith; L.A/C. F. C. Smith; A/C.1 H. W. Smith; L.A/C. G. S. Sullivan; Sgt. L.A/C. E. Thomas; Cpl. C. Thompson; A/C.2 H. F. Thornton; L.A/C. K. Turner; Cpl. G. F. Walters; Cpl. E. Watt; L.A/C. J. G. Whitlock; A/C.1 V. S. H. Wigg; L.A/C. F. A. Woodford; A/C.1 C. L. Woods.

WOUNDED OR INJURED ON ACTIVE SERVICE.—A/C.2 H. H. Blair; Sgt. N. J. L. Gillespie; A/C.1 R. D. C. Horgan; P/O. H. Marsden; Act. P/O. H. C. Nest; Sgt. S. H. Turner; L.A/C. G. W. Wilson.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Sgt. R. A. Smart; Sgt. L. H. Tickner.

DIED ON ACTIVE SERVICE.—A/C.1 D. J. Allin; A/C.1 S. J. Clarkson; Act. Cpl. S. G. Cooke; Cpl. L. J. Critchlow; Flt. Lt. E. Dawes; A/C.2 T. Duffy; L.A/C. A. Greener; L.A/C. I. A. W. Guest; Cpl. A. T. James; P/O. I. M. Kydd; L.A/C. M. McCluskey; L.A/C. E. G. Phillips; L.A/C. J. Slater; A/C.2 A. G. Townrow.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. G. O. Reynish; A/C.2 S. Sellers.

Women's Auxiliary Air Force

DIED ON ACTIVE SERVICE.—A/CW.2 M. McDonald.

Royal Australian Air Force

KILLED IN ACTION.—Sgt. C. L. Rogers.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—P/O. J. Barry; L.A/C. W. T. R. Crago.

WOUNDED OR INJURED IN ACTION.—Sgt. A. S. Collyer.

MISSING.—P/O. T. M. Clark; P/O. A. H. C. Corser; Sgt. F. W. Dennis; P/O. E. M. Harding; Sgt. G. J. Hedges; Flt. Lt. G. J. L. Jones; F/O R. H. Siggins; Sgt. D. W. Walters.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—Flt. Lt. S. Thompson; A/C.1 H. J. Webber.

KILLED ON ACTIVE SERVICE.—Sgt. J. D. Garrow; P/O. M. J. Kingshott; Sgt. W. H. D. Stewart, D.F.M.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED ON ACTIVE SERVICE.—P/O. R. R. Sly.

Royal Canadian Air Force

KILLED IN ACTION.—Sgt. D. R. Richardson.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. G. A. Bye; P/O. J. H. Purser; Sgt. K. R. Wainwright; Sgt. W. L. Waldron.

WOUNDED OR INJURED IN ACTION.—Sgt. W. J. Porritt.

MISSING.—Sgt. E. M. Brennan; Sgt. W. R. Campbell; Sgt. J. M. Cluff; Flt. Lt. J. L. Mitchell; Act. F/O. A. J. B. Monk; Sgt. D. Moss; Sgt. E. D. Simon; P/O. F. D. Simpkins; P/O. F. L. Simpson.

KILLED ON ACTIVE SERVICE.—F/O. E. J. Bounds; L.A/C. J. E. W. Gray; P/O. R. E. Holder.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. S. J. Tyson.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. J. H. Morrison.

A Polish fighter pilot who has been awarded the D.F.C. He already has the Polish *Virtuti Militari*. Names of foreign personnel may not be given because the enemy take reprisals against their families.

Royal New Zealand Air Force

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. W. L. Knowles; P/O. A. H. Wise.

MISSING.—Act. Flt. Lt. R. T. Blewett.

KILLED ON ACTIVE SERVICE.—P/O. W. W. G. Felton.

South African Air Force

KILLED IN ACTION.—Air Sgt. M. V. Clulee; Air Sgt. B. A. S. Delaney; Capt. F. W. Goch; Air Sgt. C. Jeffries; Lt. H. C. Lotz; Col. J. Mairai; Air Sgt. B. J. Reed; Air Sgt. N. J. Roodt.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—Lt. R. S. Haines.

MISSING.—Lt. L. B. Bensimon; Air Sgt. G. Brand; Lt. W. Copland; Lt. W. N. Hollenbach; Lt. E. B. M. Holliday; 2/Lt. V. Pemberthy; Lt. G. Reilly.

WOUNDED OR INJURED IN ACTION.—Air Sgt. L. J. Hyde; 2/Lt. H. Macfarlane.

Casualty Communique No. 111.

Royal Air Force

KILLED IN ACTION.—Sgt. D. Butterworth; Wing Cdr. G. P. Charles, O.B.E.; Flt. Lt. D. A. Coke; Sgt. T. A. Delaney; Act. Wing Cdr. J. N. Dowland, Sgt. S. Earnshaw; P/O. R. V. Gridley; Act. Sqn. Ldr. D. M. Ilisley, D.F.C.; Sgt. D. A. Laing; Sgt. G. E. Morrey; Sgt. J. D. Williams; Flt. Sgt. R. Watson; Sgt. L. C. Williams.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Flt. Sgt. G. H. Appleyard; Sgt. J. W. Blakey; Sgt. F. C. Child; P/O. J. E. Chilvers; Sgt. N. R. Cowin; Sgt. G. Crane; P/O. T. B. Garland; Flt. Sgt. D. C. Gordon; Flt. Sgt. A. Penn; Sgt. D. F. J. Phillips; Sgt. G. J. Truscott.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—P/O. P. G. Anderson; P/O. R. V. C. Bolster; P/O. E. P. S. Brown; Sgt. A. S. Carson; Sgt. A. B. Cooper; Flt. Lt. H. C. Down; P/O. W. A. S. Evill; P/O. W. J. Fenton; Sgt. M. C. Fuller; Sgt. A. H. Knape; P/O. I. A. Lees; P/O. E. E. Manison; Sgt. C. Meredith; Sgt. A. E. Middleton; Sgt. T. H. Mitchell; Sgt. A. McC. Morrison; Flt. Sgt. B. K. Nicholls; Sgt. S. Norcross; Sgt. T. C. Osborne; Sgt. D. Parkin; Flt. Sgt. D. D. Strickland; P/O. A. Sumner; Sgt. F. G. Taylor; Sgt. K. M. Tompkins; Sgt. D. P. Walker; Act. Flt. Lt. H. S. Young.

WOUNDED OR INJURED IN ACTION.—Sgt. E. W. Bickers; Sgt. A. Caunce; Sgt. D. T. Davey; P/O H. J. Stickings.

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—Sgt. B. Franklin; Sgt. G. R. S. Gordon; Flt. Sgt. R. M. A. Levis; Cpl. H. A. Pickering, Sgt. M. R. Willows.

MISSING, BELIEVED KILLED IN ACTION.—P/O. N. A. C. Cathles; Sgt. B. J. Child; Sgt. J. Cox; Sgt. E. G. T. Hall; P/O. W. H. Hughes; Sgt. R. W. Lawson; Sgt. A. Morris; Sgt. C. F. Myhill; P/O. S. G. Newborough.

MISSING.—Sgt. I. Allan; Sgt. T. E. Anstey; Flt. Sgt. E. C. Atkinson; Sgt. S. R. Baker; Sgt. J. F. Billett; Flt. Sgt. J. W. C. Bowie; Sgt. A. Collier; Sgt. K. A. Davis; Sgt. W. F. G. Fletcher; Sgt. D. K. Gordon; Sgt. H. J. Groom; P/O. H. G. Harris; Flt. Lt. R. E. Hill; Sgt. B. Hillman; Sgt. E. F. E. Hodges; Sgt. R. James; Sgt. R. A. Johnson; Sgt. J. E. Kitley; Flt. Lt. N. D. Lancaster; Sgt. W. Langhorne; P/O. J. B. Macleod; Sgt. W. C. Marshall; Flt. Sgt. W. W. Martin; Sgt. V. E. Miles; Sgt. D. H. Phillips; Sgt. R. A. Priestley; Flt. Sgt. R. J. Rayner; Sgt. F. G. W. Roberts; Sgt. E. G. Sawdy; Sgt. J. F. Skingsley; Sgt. E. A. Spicer; Sgt. O. C. Summers; P/O E. H. C. Theobald; Sgt. C. Townend; P/O. L. G. R. Wallington; Sgt. J. J. B. Ward; Sgt. A. C. Watt; Sgt. J. Williamson; Sgt. H. W. Wisdom; Sgt. J. W. Woodall.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—Sgt. R. G. W. Carter; P/O. N. C. Davies; P/O. R. P. Hay; L.A/C. R. H. Williams.

KILLED ON ACTIVE SERVICE.—L.A/C. E. D. Aberdeen; L.A/C. J. P. Adams; Sgt. G. T. Atkins; Sgt. F. C. Baker; Sgt. D. W. Bigglestone, Sgt. F. J. Blenkinsopp; Cpl. A. D. Blyth; Flt. Sgt. D. A. Booth; Sgt. J. C. Bradshaw; Sgt. D. Bryan; L.A/C. W. Burke; Sgt. L. Clarke; Sgt. G. B. Cowen, D.F.M.; Sgt. A. T. Crocker; Sgt. R. L. J. Edmonds; Flt. Sgt. B. D. Farmbrough; P/O A. H. H. D. Firman; Flt. Lt. S. A. P. Fischer; Sgt. G. M. Gee; Flt. Sgt. P. A. Gibbs; A/C.2 W. E. Goodwin; Flt. Sgt. R. W. G. Goold; A/C.2 W. K. Hawkins; Flt. Sgt. J. K. Henson, D.F.M.; Flt. Sgt. D. V. Hewlett; L.A/C. E. H. Hooper; Sgt. W. F. Horsham; P/O. P. H. Isted; Sgt. H. K. Jones; A/C.2 J. Jose; Sgt. J. W. Kennedy; Sgt D. Lawton; Sgt. R. W. McCoy; A/C.2 G. E. Maltby; Sgt. R. G. G. Millar; Sgt. F. R. Morris; Flt. Sgt. D. Musk; Act. F/O D. F. Newsham; F/O. C. C. Nilson; Sgt J. H. O'Connor; Act. Flt. Lt. M. G. Pascalis; Flt. Sgt. D. W. Pike; Sgt. R. Potten; L.A/C. J. F. Rimer; Sgt. E. Robinson; A/C.1 J. A. Ryan; Sgt. D. C. Scurrey; Flt. Sgt. J. W. Shephard; Sgt A. J. Sistron; Sgt. G. G. Sinclair; Sgt. H. N. Smith; A/C.1 W. Watson; Sgt. G. L. West; L.A/C. G. B. Whigham; F/O. A. L. White; Sgt. T. Williams; P/O. H. B. Wooler; Sgt. C. W. Wright; Sgt. D. Wilcox.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. E. E. Dawson; P/O. P. Dixon-Spain; Sgt. B. Halbert; Sgt. T. Morgan.

WOUNDED OR INJURED ON ACTIVE SERVICE.—A/C.2 A. T. Westby.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—L.A/C. P. E. Bushell; Sgt. T. C. Jung; L.A/C. G. B. Murphy; L.A/C. D. A. Phillips; P/O. V. H. Saunders.

DIED ON ACTIVE SERVICE.—L.A/C. H. C. J. Althaus; Cpl. F. Andrews; L.A/C. G. Bamford; L.A/C. A. Beck; Sgt. A. R. Bernard; L.A/C. H. W. Boyes; A/C.2 H. F. J. Burdett; A/C.2 R. A. D. Callaghan; A/C.2 J. H. Calnon; Cpl P. Cunningham; Cpl. A. Carter; Cpl. R. W. Clague; Flt. Sgt. S. W. Cradduck; L.A/C. L. Dixon; A/C.2 S. L. Gregory; A/C.1 F. J. Humphrey; Cpl. S. A. Johnson; L.A/C. J. Keighley; A/C.2 E. Livesey; Wing Cdr. C. T. McKnight; A/C.2 A. F. Mills; A/C.2 A. E. Moseley; A/C.1 V. J. Mulligan; Flt. Lt. A. A. Ratclyffe; Flt. Sgt. C. W. Reid; L.A.C. W. F. Shead; A/C.1 D. Vass; A/C.2 J. Whittle.

Royal Australian Air Force

MISSING, BELIEVED KILLED IN ACTION.—Sgt. W. S. C. Atherton; P/O. T. G. Moloney; P/O. J. MacG. M. Patterson.

MISSING.—Sgt. R. B. Cameron; Sgt. K. R. C. Carter; Sgt. R. W. Fisher; Sgt. G. W. Fisher; Sgt. R. H. Simes.

KILLED ON ACTIVE SERVICE.—Sgt. R. W. Allsop; Sgt. G. I. D. Backhouse; L.A/C. R. A. F. Braye; Sgt. B. B. Connell; Sgt. J. Donaldson; P/O. C. W. Head; Act. Sgt. J. B. Lockyer; Sgt. R. G. Luke; Sgt. R. B. Murphy; Sgt. H. Pusepp.

Royal Canadian Air Force

KILLED IN ACTION.—Sgt. E. A. Parsons.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—P/O. W. A. Casey; Sgt. A. H. Figg; Sgt. J. C. Hiltz; Sgt. H. Ingleby; Sgt. G. L. Olsen; Sgt. T. A. Sherman.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. F. Boroski; Sgt. H. W. McColn; Sgt. O. I. Platt.

MISSING.—P/O. M. C. Blanchard; Sgt. J. R. F. Bourgeau; Sgt. H. D. Bryant; Sgt. O. H. Burchell; Sgt. J. C. Donkin; Sgt. J. H. Durning; Sgt. J. J. Lynch; Sgt. B. P. O'Neill; Sgt. V. E. Reynolds; P/O. P. A. Scott.

KILLED ON ACTIVE SERVICE.—Sgt. W. F. Boggs; Sgt. G. C. Boudreau; P/O. R. C. Du Pasquier; Sgt. R. L. Horning; Sgt. S. S. Lang; Sgt H. A. McLennan; P/O. W. B. McManus; Sgt. W. J. Robertshaw; Sgt. W. W. Tripp; Sgt. J. M. Wilson.

DIED ON ACTIVE SERVICE.—Sgt. J. R. Chalmers; Sgt. K. W. Reilly.

Royal New Zealand Air Force

KILLED IN ACTION.—Sgt. A. G. Browne; Sgt. C. F. O'Connell.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. A. W. P. Bird.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. C. H. L. Newbery.

AVIATION

SERVICE AVIATION

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—P/O. W. H. Burnham.

MISSING.—P/O. M. J. H. Hunt; Sgt. E. B. Whitaker; Sgt. E. J. Williams.

KILLED ON ACTIVE SERVICE.—Sgt. A. G. Craig.

South African Air Force

KILLED ON ACTIVE SERVICE.—W/O. D. W. Wood.

Casualty Communique No. 112.

Royal Air Force

KILLED IN ACTION.—Flt. Lt. P. B. Alexander; Sgt G. Bedford; Sgt. J. C. Bradley; Sgt. T. Cowan; Sgt. G. T. Darville; F/O. R. C. Derrick; Sgt. W. Godderidge; Sgt. E. B. Harper; Sgt. J. T. Howe; Sgt. J. Johnstone; P/O. D. S. Matthews, D.F.M.; P/O. M. J. Mortimer; Sgt. D. T. Neale; Sgt. R. V. Pardy; Sgt. T. I. Roberts; Flt. Lt. S. C. Romer; Flt. Sgt. L. Sieve; Sgt. G. G. Taylor; Sgt. H. K. Taylor; Sgt. F. E. Thomas; Sgt. J. Turnbull, D.F.M.; Sgt. M. R. Walker; Flt. Sgt. B. C. Wescombe; Sgt. C. R. Westbury; Sgt. F. A. Westkemy; Sgt G. White; Sgt. J. Wilmot; P/O. T. I. R. Wilson.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. A. J. Arnold; Sgt. J. Austin; Sgt. P. Bratley; Sgt. R. S. Bunce; Sgt. A. G. Burbridge; Sgt. J. K. Cassells; P/O. R. S. Chisholme; Sgt. G. G. Eanouf; Flt. Sgt. C. A. Godwin; Flt. Sgt. A. Greensides; Sgt. J. Guest; Sgt. E. Halestrap; P/O. A. V. J. Hardcastle; Sgt. J. N. Harrison; Sgt. D. A. Humphrey; Sgt. H. Jackson; Sgt. J. E. Jerrard; Sgt. G. Klusky; F/O. D. F. Lamb, D.F.C.; Sgt K. J. Lord; Flt. Sgt. D. J. Mansfield; Sgt. K. Morris; Sgt. C. H. Newstead; Sgt. C. J. Partington; Sgt. W. McL. Ritchie; Sgt. L. N. Rowbotham; Sgt. R. T. Rudlin; Sgt. R. C. Scott; Flt. Sgt. S. H. J. Shirley; Act. F/O. W. C. Taffender; P/O G. A. Tovey; P/O. E. D. Vivian; Sgt. J. H. Williamson; Sgt. D. G. Woodward.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—P/O. S. R. Andrews; Act. Flt. Lt. J. A. J. Bailey, D.F.C.; Sgt. A. Ball; P/O. A. Bleakley; P/O. D. M. Bolton; Sgt. S. Bridges; Sgt. D. G. A. Briers; P/O. A. W. Camp; Sgt. D. G. Clark; Sgt. E. Clarke; Sgt. R. J. Clifton; Flt. Sgt. B. J. Conlon; Sgt. K. E. Corrie; Sgt. D. W. Crump; Sgt. M. K. Daniels; Sgt. R. D. Davidson; F/O. C. V. Fraser, D.F.C.; P/O. A. F. George; Flt. Sgt. R. M. Gray; Sgt. J. H. Grubb; Flt. Sgt. H. F. Hancock; Sgt. J. B. Hancock; Sgt. J. A. Harris; Sgt. E. Johns; P/O. M. N. F. Jones; Sgt. F. T Luscombe; Sgt. S. W. McIntyre; Sgt. W. W. Melville; Sgt. R. D. Mills; Sgt. J. A. Mortimer; Flt. Sgt. W. Myles; Sgt. F. R. Nichols; Sgt. A. P. Nicoll; Flt. Sgt. P. D. Nicolson; P/O. L. B. O'Reilly; Sgt. E. T. Panes; Sgt. R. S. Peck; F/O. P. S. C. Pollard; Flt. Sgt. A. Pratt; Sgt. E. H. Rogers; Sgt. L. A. Slade; Sgt. P. B. E. Smith; P/O. G. W. Tetlow; Sgt. W. Thornhill; Sgt. G. Wale; Sgt. W. R. Welch; Sgt. E. G. Whitehead; Sgt. W. Wilcox; Flt. Sgt. A. N. Wynne.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—P/O. J. R. Stideford.

WOUNDED OR INJURED IN ACTION.—P/O. K. Blyth; Sgt. F. Colville; Flt. Sgt. W. O. Morgan; P/O. T. C. Rigler; Sgt. E. C. Smith.

MISSING, BELIEVED KILLED IN ACTION.—Act. Flt. Lt A. J. F. Allen-White; Sgt. W. J. Cuming; Sgt. J. H. Pilley, D.F.M.; Sgt. R. Tollett.

MISSING.—Sgt. B. A. Adams; P/O. W. Anderton; Sgt. L. A. Angel; Sgt. A. S. Austin; Sgt. R. A. Baddeley; Sgt. H. J. Bye; Sgt. W. Cannon; Sgt. N. D. Clayton; Sgt. D. W. Cockburn; Sgt. R. Cooke; Sgt. R. M. T. Draper; Sgt. R. B. H. Driver; Sqn. Ldr. M. F. C. Farrar, D.F.C.; Sgt. J. R. Fenwick; P/O. J. Fortune; Sgt. G. A. Gale; Sgt. A. L. Gardner; Sgt. C. K. Gorman; Sgt. T. J. Goggin; Sgt. C. H. Hall; Sgt. E. Hill; Sgt. F. Hinton; P/O. E. V. Hore; Sgt. J. M. Horley; P/O. D. A. Howard, D.F.M.; P/O. D. C. Hunter; P/O. W. B. Inabinet; P/O. L. M. Jacob; Sgt. R. B. Kinnell; Sgt. J. H. Lowry; Flt. Sgt. K. McKenzie, D.F.M.; Sgt. P. C. Pettersson; Sgt. J. Priestley; P/O. G. W. Ratlidge; Sgt. E. J. Richards; Sgt. C. D. Russell; Sgt. R. P. H. Sperring; F/O. F. W. O. Street Porter; Sgt. W. G. Tate; Sgt. T. H. Thomas; Sgt. P. J. Timmons; Sgt. R. N. Whatley; Sgt. R. J. White; Sgt. R. W. Whitehouse; Sgt. J. Wild; F/O. S. P. Wilkins; Sgt. J. A. Willis; Sgt. J. W. Young.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—P/O. W J Henderson; Flt. Sgt. J. L. Roberts; Sgt. R. M. Shaw; Flt. Sgt. F. G. E. Tizard, D.F.M.

KILLED ON ACTIVE SERVICE.—A/C.2 H. Amoore; Cpl. C. W. Arnold; L.A/C. R. W. Banks; L.A/C K. Barless; Sgt. W. R. Beeton; Sgt. R. F. Bishop; Sqn. Ldr. W. S. Bowyer; Sgt S. R. Bult; A/C.1 A. G. Cocklin; L.A/C. R. B. Crossley; Sgt. D. H. Faith; A/C.1 H. A. W. Greenacre; P/O. A. A. W. Harris; Sgt. S. C. Lester; Sgt. S. A. Orford; L.A/C. R. S. Palmer; Sgt. P. Pantoock; Sgt. A. W. Savage; Cpl. J. H. A. Small; L.A/C. K. N. Thomson; Sgt. G. C. Townsend; L.A/C. R. Watson; Sgt. M. H. Welch.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. G. Mason; Sgt. C. F. Matthews; P/O. G. A. Prosser.

WOUNDED OR INJURED ON ACTIVE SERVICE.—A/C.1 K. Bell; A/C.1 W. H. Blundell; L.A/C. A. F. N. Bradley Sgt. A. J. Brown; L.A/C T. Bruford; L.A/C. J. D. Garroway; Cpl. W. H. Golder; L.A/C. D. Hawkins; L.A/C. E. J Head; A/C.1 J. W. Loosemore; L.A/C. R. W. Mann; Act. W/O. A. Mounsey; P/O. A. P. Skinner; L.A/C. M. A. Swain.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Cpl. J. Birkett; L.A/C G. W J. Dodge; A/C.2 W. M. Hetherington; P/O. J. C. Huston; L.A/C. J. Sim.

DIED ON ACTIVE SERVICE.—A/C.2 S. P. Astington; Flt. Sgt. C. W. Cotterill; Sqn. Ldr. F. J. Gracey; L.A/C. C. W. Hall; A/C.1 W. H. Hambly; A/C.2 H. R. Johnston; Sgt. S. R Noon; L.A/C. P. J. Tarbuck; A/C.1 C. V. Windmill.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Flt. Lt. A. M. Brown; A/C.2 M. Slor.

Royal Australian Air Force

KILLED IN ACTION.—P/O D. N. Carmichael; P/O. E. J. N. McDonald.

WOUNDED OR INJURED IN ACTION.—P/O D. Hersey.

MISSING.—Act. Flt. Lt. B. J. Adam; P/O E. G. Broad; Sgt. W W. Forgan; P/O. R P. Hickey; Sgt. B. W. Johnstone; Sgt. P. C. Voller.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE.—Sgt. H. L. Gibson; Sgt M H. Wadham

KILLED ON ACTIVE SERVICE.—Sgt. J. H. Rogerson; Sgt. W. K. Sloggatt; Sgt. E. F. Webb; Sgt. F. E. Williams; Sgt. J. S. R. Woolnough

WOUNDED OR INJURED ON ACTIVE SERVICE.—Cpl. A. Campbell; Sgt. A. C. K. Parsons.

Royal Canadian Air Force

KILLED IN ACTION.—Sgt. V. L. Brice; Sgt. D. Savage; Sgt. J. B. Turner.

WOUNDED OR INJURED IN ACTION.—Sgt. J. A O. Attwell; Sgt. W. J. Hegan.

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—Sgt. A. W. Reimer.

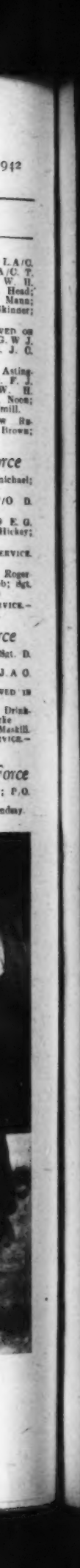
MISSING.—Sgt. S. C. Camp; Sgt. K. G. Drinkwater; P/O. A. J. Fraser; Sgt. W. G. Yorke

KILLED ON ACTIVE SERVICE.—Sgt. D. J. Mastill.

WOUNDED OR INJURED ON ACTIVE SERVICE.—F/O V. E. Tapp.

Royal New Zealand Air Force

KILLED IN ACTION.—Sgt. D. R. Bradley; P/O. M. Von Dadelszen.

MISSING.—P/O. R. Birnie; P/O. R. G. Lindsay.

Handing up the twin Vickers K guns for the lower rear gun turret of a Hampden.